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The International Air Passenger Station of Pan-American Airways, Inc., at Miami, Fla.
(Times Wide World Photos)

CIVIL AIRPORTS AND AIRWAYS

BY

ARCHIBALD BLACK

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Society of Automotive Engineers, Etc.

With the collaboration of a group of
19 specialists in the different angles of
airport construction and equipment.

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A Dedication

TO THE MEMORY
OF THOSE PILOTS
WHOSE LIVES WERE
SACRIFICED TO INADEQUATE LANDING
FIELDS

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PREFACE

This volume has been compiled with the purpose of providing in convenient form a mass of information on airports and airways design which has been accumulated in the past several years and which has been discussed, in part, by the author in numerous technical articles.

Almost as soon the work of preparing this book was started it became evident that a radical departure from customary text-book practice was desirable. Airports and airways include so many varied kinds of specialized knowledge that no one engineer can expect to properly cover the entire field. Hence the airport engineer, while having *some* knowledge of each of the specialized problems, must assume the position of coordinating the work of many others.

No effort was made, therefore, to prepare this book single-handed. Instead its author engaged the interest of a large group of men,—each a recognized specialist in his respective field of work. The entire volume was then prepared by working in close cooperation with these men. In the case of the airship and radio Chapters this policy was carried even further and the material prepared by engineers specializing in these fields.

It is not by chance that all of these men are civilians. Intended for civil use it seemed only logical that all of the information should come from civil sources and that military and naval aspects should be subordinated so far as possible. Although a few parts of the work have been based upon articles published by the author several years ago, these portions have been included only after a most thorough revision and the greater proportion of the material in this book has never been published before.

For their generous cooperation in permitting the use of illustrations and other such material thanks are hereby extended to: Aerial Age; Aero Digest; Airway Age; American Machinist; Aviation; Engineering News-Record; Engineers and Engineering; Landscape

Architecture; Mechanical Engineering; National Municipal Review; Safety Engineering; The American City; U. S. Air Services Magazine; Aeronautical Chamber of Commerce of America; National Advisory Committee for Aeronautics; Office of the Assistant Secretary of Commerce for Aeronautics; the various manufacturers of equipment and those others to whom credit is given thoughout the following pages.

ARCHIBALD BLACK

Garden City, N. Y.
January 1929.

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CHAPTER I

PUTTING THE CITY ON THE AIRLINE

The U. S. A. Forging Ahead in Aviation.

Civil flying in the United States is increasing by leaps and bounds. A few short years ago we lagged behind Europe; today we lead the world. The reversal was so sudden and came so recently that many are not yet fully aware of the change. Our country is now covered with a network of airlines carrying mail, freight and passengers. Traffic is being developed and, already, many operators report profits and are planning important extensions. Following the precedent established in the creation of waterways, the Department of Commerce a few years ago embarked upon a comprehensive program of airways development* and has already completed the lighting of several thousand miles of routes. Every indication now points to a repetition, in air transport, of the tremendous railroad expansion of the last century. And just as this railroad development altered the destiny of towns, so may air transport be expected to leave its mark even when allowance is made for the differences in kind. Certainly, then, the local airport should be a subject worthy of most careful consideration by all interested in the growth of their city.

The "Need" for a Local Airport.

Every city wants to be "on the airline" just as it wanted to be on the railroad a generation or two ago. Such location is rapidly

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* To avoid misunderstanding, it might be well to mention here that the establishment of airports has become recognized as a *local* function—to be taken up by local government or private enterprises. The activities of the Federal Government are confined by law to the establishment and maintenance of the airways between these airports.

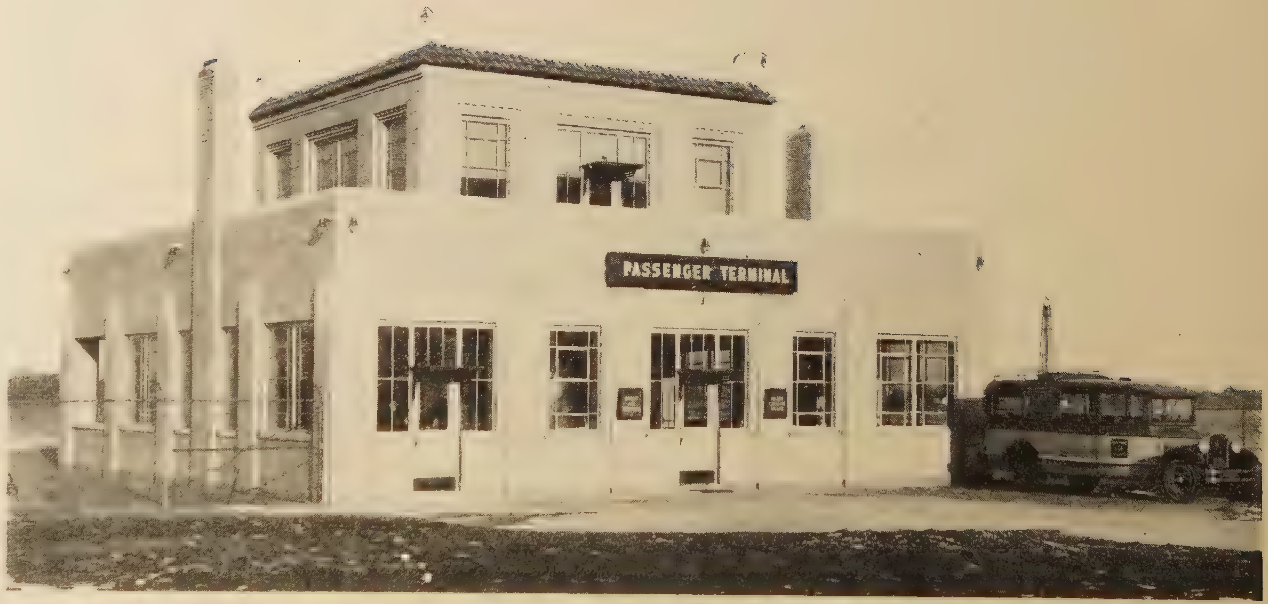

Fig. 1.—Terminal of the Stout Air Services Detroit-Cleveland line at Ford Airport, Dearborn, Mich.

becoming of great importance to all cities and will become of vital import to some. It is not a matter to be relegated to a pigeon hole for attention at some distant date, but rather something calling for thorough investigation at the earliest opportunity. Existing local interest in aviation may be a dangerous guide to follow in this respect. Without the airport there can be no local flying anyhow. And the city that waits for interest to develop of itself may find that some nearby town has shown more vision and got there first. Whereupon the air transport route passes by. For one city, more or less, makes little difference to the airline,—but the airline makes a lot of difference to that one city.

The City or a Public-Spirited Group Should Control the Site.

Strange though it may sound, most cities have only a few sites which are entirely suitable for aviation purposes. If these are left to be developed by purely selfish interests, tomorrow the city may find itself at the mercy of these interests so far as rapid intercity transportation is concerned. The obvious solution lies in provision of an airport owned or controlled by the municipality or by a public-spirited group of men who make it open to all on fair terms. Hangar space and other facilities can be leased to private owners of airplanes, small operators and to air transport firms when the last-mentioned serve the city in question. Such arrangement, if the site is carefully selected and the arrangement properly planned, puts the city in control of the situation from the start. In addition, it offers the greatest possible inducement to air transport firms and to occasional flyers to make that city a stopping point on their way, if not indeed the end of their journey. This is becoming so well appreciated that some 425 municipal and 415 privately-owned flying fields are already recorded by the Department of Commerce as in use in the United States. In addition to these there are 80 military flying fields and 644 marked intermediate or auxiliary fields, —a grand total of 1,564 fields. Some 942 others are under consideration throughout the country and will be placed in operation during the next few years.

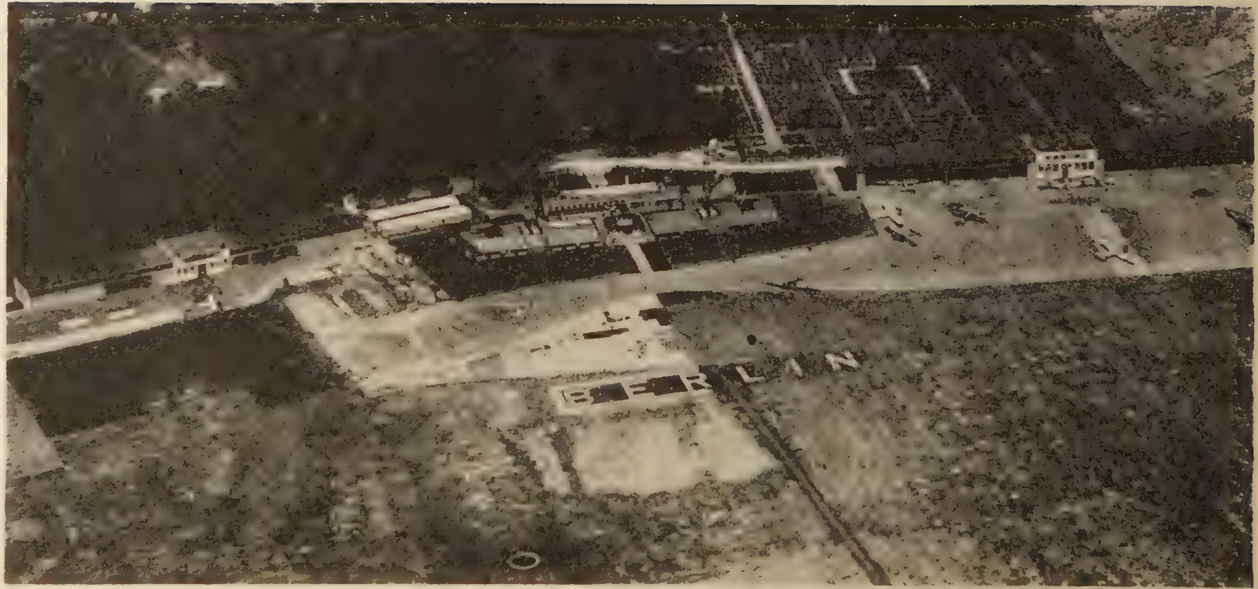

Fig. 2.—Tempelhof Field, Berlin. This field is usually conceded to be the most conveniently located of European airports.

Airports vs. Railroad and Marine Terminals.

While the growth of air transport should, in many ways, parallel the early development of railroads, some important differences must be recognized. To begin with, the railroad is inherently and unavoidably a monopoly. Being relieved of the necessity of controlling a continuous strip of land from city to city,—as the railroad must,—the aircraft operators escape some of the elements which forced railroads into the realm of natural monopolies. The airline can depend largely upon government-owned, marked, and lighted airways just as shipping depends upon waterways dredged, marked, and lighted by the government. Here the parallel with shipping begins to fade. For the airline must have a terminal convenient of access from the center of each city which it serves. It may be argued that both shipping and railroads require this also; but loss of time is of minor importance in maritime and railroad operations as compared with air transport. The scheduled speed of passenger ships ranges from 12 to 25 miles per hour, the latter figure being an unusual achievement. Passenger railroad trains seldom average more than 40 miles per hour from city to city. On the other hand, the scheduled speed of airplane lines is about 90 to 110 miles per hour or even more, while that of airships is only slightly less.

The Importance of Airport Location.

These figures give us some measure of the relative importance of terminals. As a general rule in transportation the importance of convenient terminal location varies inversely with the time required for transit. Hence it should be obvious that terminal location is of *more importance* in air transport than in any other form of long-distance transportation. Reduced to figures, terminal location in air transport is from 2½ to 5 times as important as it would be in railroad and maritime operations. This viewpoint gives a new light on the airport subject. It becomes obvious that the air-transport operator with the best terminal location at each city may be expected to dominate the air traffic of that city. Similarly, the city which has the most convenient airport will be able to utilize air transport to its greatest advantage.

The Question of Airport Control.

Both the city and the transport operator will become interested in control of the airport. At present air transport operators are content to use public facilities, merely renting landing rights and hangar space. This condition may be doomed by the natural growth of traffic. Long before the volume of air traffic approaches that of the railroads, the large operator may find it necessary to either crowd the others off the field or to move to his own airport. It is at this stage that the vital importance of not merely terminal location but also its *control* will become evident. The far-sighted operating company will anticipate such development and will secure adequate rights for itself in advance. The city, on the other hand,

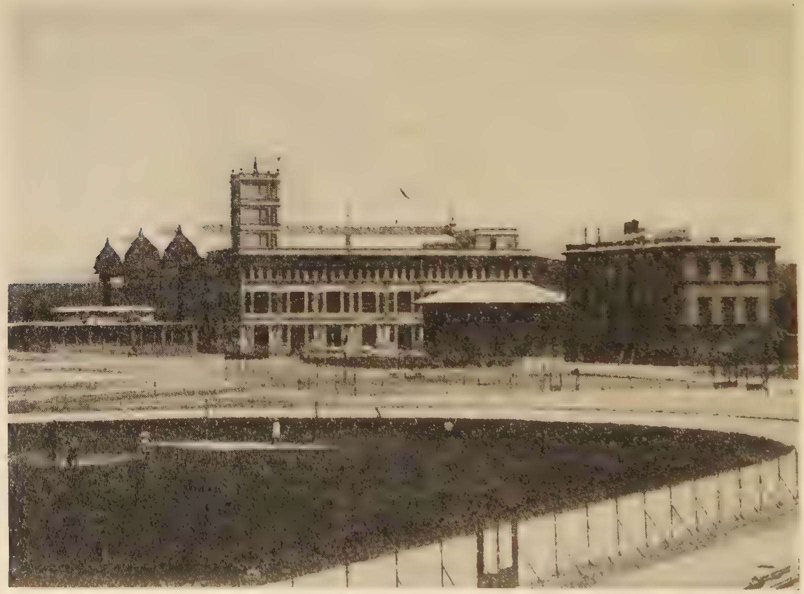

Fig. 3.—The double-deck hangar at Littorio Airport, Rome, Italy. Small airplanes are housed on the lower floor and large ones on the upper.

becomes equally interested and must obtain either direct or indirect control of an adequate airport if its air transport connections are not to be entirely dominated by some one large operator. Direct control may be attained by municipal ownership; indirect control through ownership by a body of public-spirited citizens.

Steps in Providing a Public Airport.

When a city decides to establish a public airport, the first step should be that of appointing an Airport Committee formed of public-spirited men. The work of this Committee would be that of studying possible sites within the city limits, or sufficiently close to these for practical purposes. This is somewhat of an involved and technical matter, and it should be handled by an airport specialist engaged by the Committee for the purpose. In the primary selection of sites, the elements listed below should be given consideration, not necessarily in the order given but as will be discussed in detail in later Chapters. The report should be prepared by some engineer who is sufficiently familiar with every one of these elements to intelligently balance each one of them against the other:

1. Suitability for airplane use.
2. Suitability for seaplane use.
3. Suitability for airship use.
4. Meteorological conditions throughout the year.
5. Location with reference to other airports, the airway, the post office and centers of business and social activities.
6. Type of soil and its drainage.
7. Transportation facilities.
8. Communication facilities.
9. Available water supply, electric power, etc.
10. Surrounding territory and its effect upon use of the site.
11. Existing obstructions and approaches.
12. Local meteorological characteristics which might affect use of the site.
13. Extent to which the airport may be used immediately and in future.

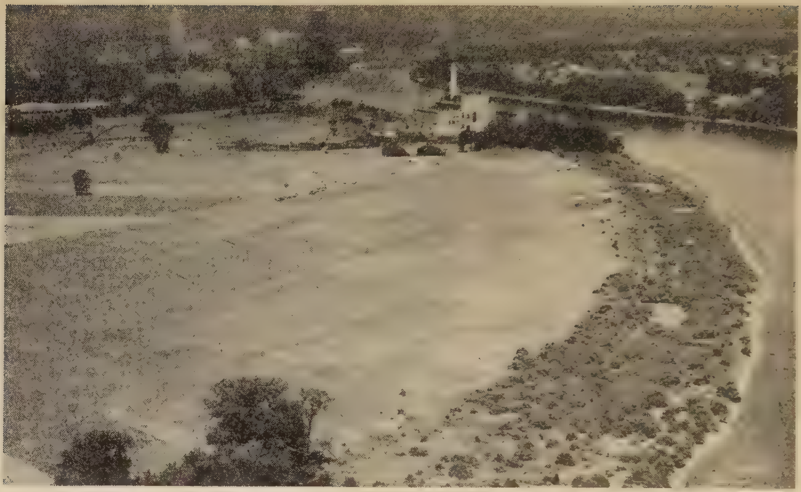

Fig. 4.—Brainerd Field, the municipal airport of Hartford, Conn., and a station on the New York-Boston route of Colonial Air Transport.

14. Cost of the property.
15. Possibilities of traffic development and other business considerations.

Consideration of Sites.

After the various sites have been investigated along these lines, it will usually result in elimination of most of the original list. It is frequently surprising how the study becomes confined to one or two sites. The next step, before acquiring any property, should be the preparation of rough, preliminary layouts for each of the remaining sites. These layouts should be just sufficiently in detail to show which site is the most satisfactory all-around, considering cost, safety and general suitability as discussed in succeeding Chapters. A report, recommending a certain site or sites, can then be prepared, and the next step becomes that of negotiating for the lease or purchase of the most desirable site. Just how much of the report on the site should be made public before negotiations are closed will depend upon local conditions. As the property being considered will not usually be a class which changes hands frequently, it may be possible to obtain a short-term purchase option without cost and as one of the conditions of consideration of each site. This would eliminate attempts to increase the asking prices for properties upon completion of the report.

Arrangement of the Airport.

When the proposed arrangements of sites are being worked out on paper, each of the features previously mentioned should be considered. In addition, careful consideration should be given to each of the following additional points:

16. Orientation of the site to be purchased.
17. Arrangement of runways for taking-off and landing.
18. Grading and surfacing of field.
19. Drainage of field, if required.
20. Arrangement of seaplane launching ways, if any.
21. Location of mooring space, fairway and channel, if to be a seaplane station.
22. Building arrangement.
23. Provision for future expansion, either on property being considered or on adjoining property.

After the matter of acquisition of the site has been disposed of, and when the final plans for the airport are being prepared, the following points should be added to those already given for consideration:

24. Building construction.
25. Runway and roadway construction.
26. Fire protection and insurance considerations.
27. Field markers for identification from the air.
28. Airport maintenance equipment.
29. Airport operating equipment.
30. Aircraft repair equipment.
31. Night flying and radio equipment.

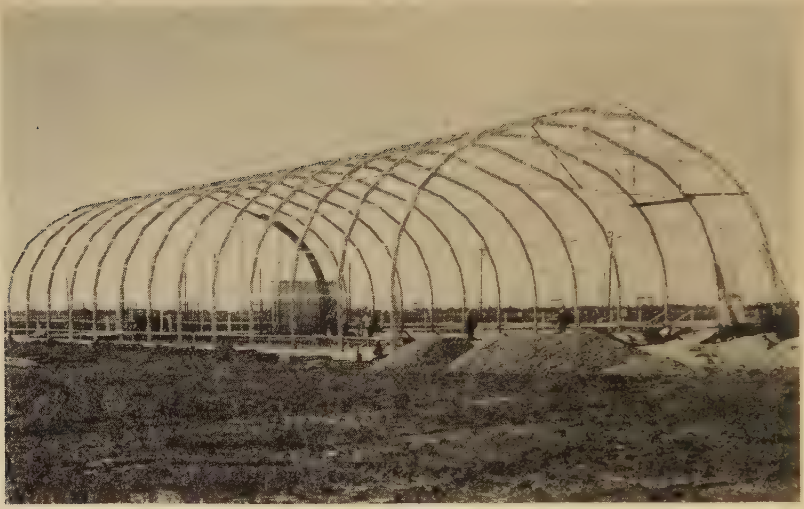

Fig. 5.—The completed framework of one of the arc-welded steel hangars erected at Houston, Texas, Municipal Airport.

These points also will be taken up later and requirements discussed in detail. Once more, it seems advisable to stress the importance of having this work properly balanced,—ability to do this balancing of conflicting requirements is the chief asset of a competent airport specialist.

What is Immediately Necessary for an Airport.

It is not essential that the airport be completely equipped at the start. What is far more important is the provision of a suitable site with perhaps limited equipment, but the development of which has been started along the lines of a comprehensive plan contemplating the possible future rating by the Department of Commerce and including provision for additions to the buildings and equipment from time to time as conditions warrant. The first essential is the provision of suitable areas for airplanes to take off from and to land upon. (If the airport is to provide for seaplanes, some launching rails, or similar means, will also become essential.) The dimensions of take-off and landing areas and the arrangement required will be affected by the shape and altitude of the field, types of machines and other considerations to be taken up in later Chapters. However, for sea-level and for average airplanes, they should be about 2,500 to 3,000 feet long. The best arrangement is *usually* obtained by the use of a round plot, or by use of a square plot with take-off areas or runways placed diagonally on it. However, L- or T-shaped plots can often be used. Local conditions have a very important bearing upon the take-off and landing areas and must be taken into consideration. Where T or L shapes of fields are used, the legs of the T or L should not be less than about 1,000 feet wide. The site should be reasonably level; all mounds should be removed and hollows or ditches filled. A crop of tough, all-year grass should be raised, and, if the soil drains poorly, an effort should be made to provide at least some artificial drainage. These considerations will be taken up in detail in subsequent Chapters and reference made to Department of Commerce regulations.

The First Essentials.

As regards the buildings and equipment, the most advisable policy is that of developing a complete building arrangement in the plans and then providing only such items as gasoline and oil storage facilities, wind indicator, field marker, fire extinguishers, telephone connection, some water supply and such hangars as are required for immediate needs. As the use of the airport grows other buildings and equipment can be added in accordance with the original plans. Only in this way can a really systematic arrangement be obtained when the airport is fully developed at some future date. To sum up, the urgent necessities are three: (1) Get a suitable site under proper control. (2) Prepare a comprehensive plan for its ultimate development. (3) Construct as much of the planned development as available funds and immediate use of the airport will justify. Above all, do not attempt to acquire any site, or to arrange an airport, without capable advice, and do not rely greatly upon the advice of some ex-flyer who may have an excellent war record but who has

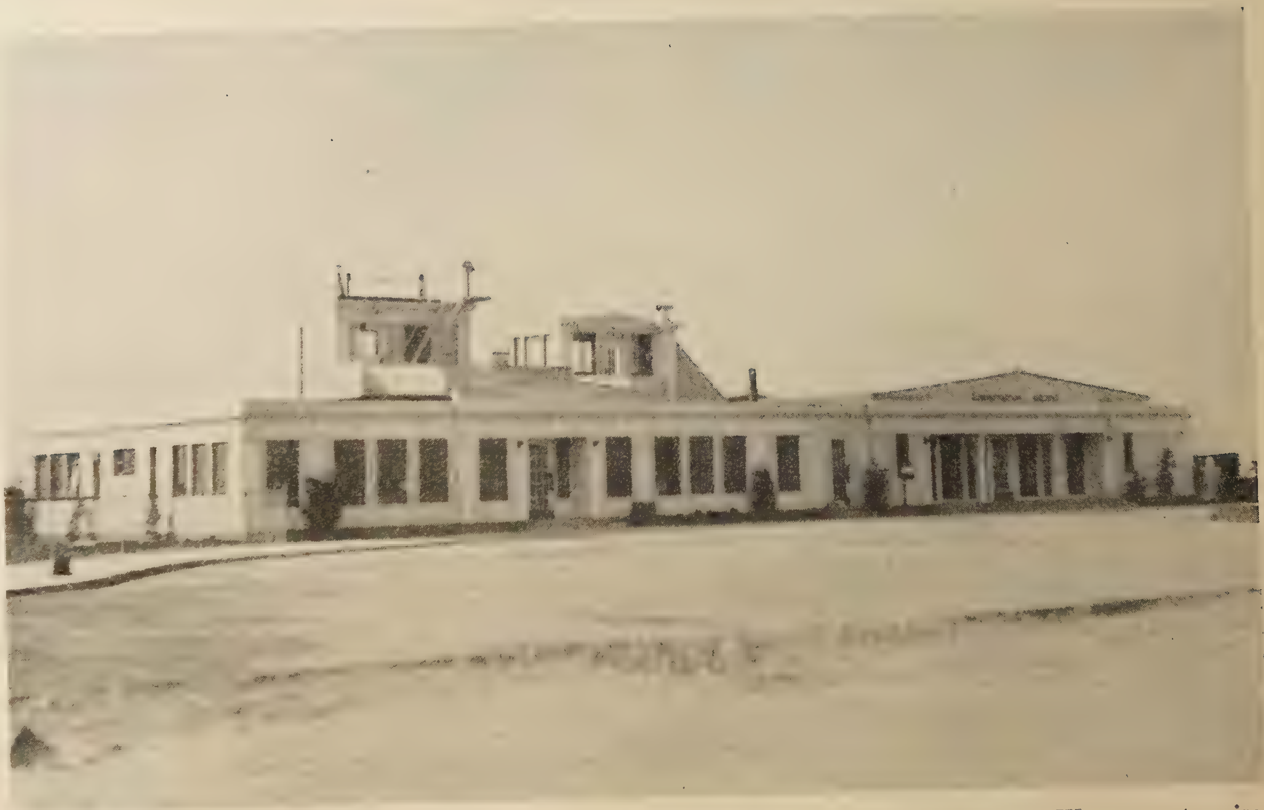

Fig. 6.—The Administration Building at Oakland, Calif., Municipal Airport, is a monument to Western enterprise.

not been in close touch with the tremendous development of the past ten years. This advice, if followed, will certainly save money, and (what is much more important) it may save lives later on.

The Question of Income.

Whether or not an airport can be made to pay depends upon considerations which are subject to great variation. The major expenses of operation (not necessarily in their order of importance) are usually: (1) Rent or interest on investment; (2)salaries and wages; (3) gasoline and oil costs; (4) light, heat, power and telephone; (5) taxes, insurance and incidentals. The income (also without regard to relative importance) is usually derived from such items as: (1)Hangar rent and use of field; (2) gasoline and oil sales; (3) roadside refreshment stand, automobile parking, or other concession; (4) revenue from periodic flying meets; (5) miscellaneous items of minor importance. Hangar rents vary according to the airport, size of airplane, conditions governing use of floor space and other causes. A certain flying field, which represents perhaps a typical case, charges $2.00 per day, $30.00 per month, or $300.00 per year for hangar rent for each medium-sized airplane. These rates, in accordance with a generally established custom, include moderate use of the flying field. Passenger-carrying and similar concessions are not included in the rates given. Special rates are made for rentals when airplanes are to be placed in "dead storage" in the hangars or merely tied down to the field out of doors. The revenue obtainable from an airport is often governed mainly by the enterprise and energy with which the manager or promoter develops sources of revenue. Hence generalities are dangerous, and each case must be investigated on its own merits.

CHAPTER II

SELECTION OF AIRPORT SITES

A Problem for Careful Attention.

The first problem confronting any body or individual interested in the establishment of an airport is that of selecting the site. This question is not one to be hurriedly passed over, as mistakes are much easier to make than to rectify. Once an airport has been constructed, its location must usually be regarded as permanent through the prohibitive cost of moving to a new and more suitable site. Numerous examples could be cited to show the necessity of intelligent selection of sites. The neglect of one single factor in considering a location for a certain foreign airship station proved so serious that it forced abandonment of the partially completed station, with a resulting total loss of some $2,000,000. Croydon Field, the world-famous airport of London, underwent some drasitc and rather expensive changes which the first few years of operation had shown to be necessary.

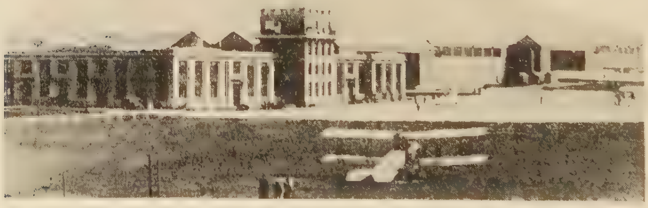

Fig. 7.—Some of the new buildings at Croydon, the chief airport of London.

Airport Engineering Often Neglected.

When the United States entered the World War we had few landing fields, and no one had given the matter really serious consideration with the exception of a limited number of cross-country pilots. Many of the Army fields had to be built under pressure of war necessity and were consequently laid out by construction firms entirely unfamiliar with aircraft work. In addition to being products of a bygone age in aviation, these wartime fields were laid out with regard more to military requirements than civil needs. Hence they frequently failed to meet the latter. During the past several years civil aviation has seen substantial development, and much has been learned about the requirements of airports for commercial and private use. Some older ideas about field arrangement have been upset, and something has been learned about the efficient utilization of available ground. Now that we have had the opportunity to learn where fields should be located and how they should be arranged, it is time to review the lessons of the past and apply them intelligently to the problems of the future. Only in this way can airport work be placed upon a practical basis.

The Cost of Neglect.

Bad judgment in selection and arrangement of airports levies, from the start, three taxes upon life and property. First, there is the ever-present risk of "crashes" due to a poor arrangement. Second, there is the waste due to this poor arrangement requiring more area than would be necessary for one properly planned. This, of course, results in greater initial cost and increased carrying charges. Third, there is the waste due to poor transportation and other facilities which will greatly retard the actual use of the airport. As commercial aviation develops each of these features will become increasingly important. In the case of competing air-transport companies, it is conceivable that the increased cost due to operation of poorly located or badly arranged terminals might be sufficient to drive one or the other out of business. A study of some airport arrangements, proposed several years ago by promoters of some air transport lines, showed that the necessary rental or investment charges would be tripled by their plans had they been carried through. And this increase would be without any improvement in safety or convenience. In the case of rival cities the one with the best airport facilities will certainly get the air transport routes and with these the cream of the fast traffic. The convention city of today may thus find itself on a side track tomorrow, if this airport question is neglected.

Some Elements to Be Considered.

Before going into more detailed discussion of the elements to be considered, two points should be emphasized here: (1) No proposed airport site should be considered by itself. The complete chain of fields along the airway, existing or contemplated; the territory between these and the meteorological conditions along this airway should all be taken into consideration at once. (2) From the very start of the project fullest consideration must be given to the "Airport Rating Requirements" promulgated by the Department of Commerce for projects in the U. S. A. (Appendix 9) and to corresponding regulations in other countries.

The viewpoint of the pilot alone is not sufficient in airport work. This is particularly true if he happens to be a former war pilot who has not kept in touch with recent developments in aviation. His advice is absolutely necessary, but the general plan, meteorological aspect, ground preparation, drainage, fire protection, communication, transportation, equipment needs, types of aircraft, provision for future expansion, business development posibilities, and many other points which will be taken up later, must all be considered simultaneously. Each of these is somewhat of a specialized field of work and proper coordination requires the services of some engineer familiar with the whole problem and who is thus equipped to balance all of the many (and often conflicting) elements to be considered.

Among the most important elements to be considered are many which can be more readily understood by the layman if we digress for a few pages to consider how airplanes take off and land.

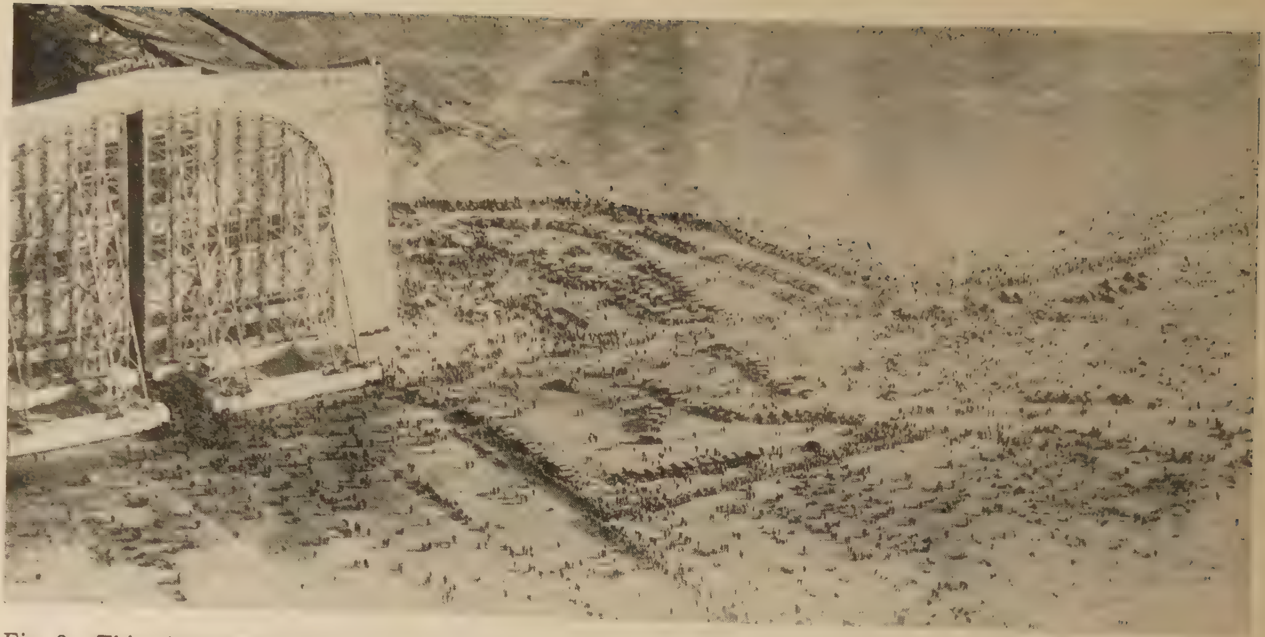

Fig. 8.—This photograph of the crowds at Lakehurst, N. J., awaiting arrival of the Graf Zeppelin, shows the necessity of provision for spectators at airports.

Taking-Off Procedure.

The procedure followed in taking off and landing airplanes is a very familiar story to those who come into daily contact with aviation. However, as this volume is written also for those who are not so familiar with flying, it seems advisable to describe these operations in detail, even though the descriptions may seem ridiculously elementary to those who know something about aviation. Preparatory to taking off, the airplane is "taxied" (that is, run on the surface under its own power) to the starting point at the leeward side of the field. To make best use of the available field area, a careful pilot starts from close to the fence line so that he has ahead of him the longest possible run into the wind. From this position facing the wind and with the greater part of the field ahead, he starts his machine across the field with the throttle wide open, accelerating as rapidly as possible, meanwhile keeping the tail of the airplane off the ground to decrease its air resistance. The length of run required to attain flying speed depends upon wind, field, machine and to some extent upon the pilot. For normal conditions and a well-loaded commercial airplane of the land type it will range between about 300 and 1,000 feet, rarely (although sometimes) exceeding the latter. The distance for water types is considerably greater and will be touched upon in a succeeding Chapter. As soon as sufficient speed is attained to enable a safe take-off, the pilot uses his elevators to bring the tail down and thus increase the angle of incidence of the machine, whereupon it lifts off the surface and starts to climb.

Leaving the Airport.

The height to which this climb is carried before the pilot levels off into horizontal flight is entirely a question of choice and surrounding conditions. Some pilots prefer to circle the field while climbing to this altitude, but the tendency today is toward climbing out of the field in a straight-line flight along the course unless some obstacle interferes or the surroundings are bad. If the engine misses fire, or if other trouble shows up just as the pilot is climbing out of the field, he immediately proceeds to land again. *This is the determining factor in fixing the size of the field required.* Where the position of the airplane permits this landing to be made without turning, the pilot makes a steep glide back to the surface in a forward direction. With a small field, or if the machine is close to the field line, a turn is necessary to effect a landing. Turning at low altitudes in this manner is dangerous and has been the cause of many accidents. Hence it becomes advisable to make the field limits such that sufficient altitude for a safe turn can be attained, or the machine brought down in a straight-line glide, without danger of collision with the fence. Under normal conditions and with a fairly well loaded airplane, a distance of 2,500 feet will usually provide this, but a length of 3,000 feet is advisable. Later in this Chapter consideration will be given to variation of this distance and the factors governing it.

Landing Procedure.

The pilot flying across country approaches the airport usually at an altitude of one or two thousand feet, although some pilots fly lower. As soon as he comes within gliding distance of the field he throttles down his engine and proceeds to glide into the field. If approaching a strange field or one which is very active he usually circles it once to look things over before "coming in."* He then maneuvers his airplane so that it is gliding into the wind while approaching the airport at an altitude of 50 to 200 feet or more, depending upon field, surroundings, size, wind, etc. From this height he makes a slow glide into the field and down to within a few feet of the surface. Flattening out his glide by increasing the angle of incidence of the airplane, he then allows his machine to gradually settle on the surface of the field while moving forward at about its lowest speed.

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* As the amount of civil flying grows in volume, several airplanes may arrive simultaneously—forcing incoming pilots to make a practice of circling the field in the air while awaiting signal to land. This is already a frequent occurrence at some of our busy airports and brings up the question of traffic control, which will be discussed in subsequent Chapters.

The Landing Run.

The horizontal distance required for "flattening out" is about 100 to 200 feet, depending upon the pilot, airplane, wind and other conditions. The machine is maneuvered, of course, so that the actual contact with the ground is made as soon as possible after passing over the line of the fence. This distance (from fence line to point of contact) again is dependent upon field surroundings, wind and other conditions. While difficult to give it a definite value, the variation may range from 300 to 1,000 feet according to those conditions. After landing, the airplane will roll across the field for a distance of 150 to perhaps 1,200 feet, depending upon whether or not wheel brakes are used and upon wing loading, wind, airbrake effect of wings and body, rolling resistance, etc. This run for a fully loaded large passenger type is usually about 700 to 1,000 feet if wheel brakes are not used. In cases of airplanes having wheel brakes, the landing run from the point of first contact will be much less—probably only 150 to 300 feet. However, fields must be designed for the airplane without wheel brakes, as this represents the worst condition

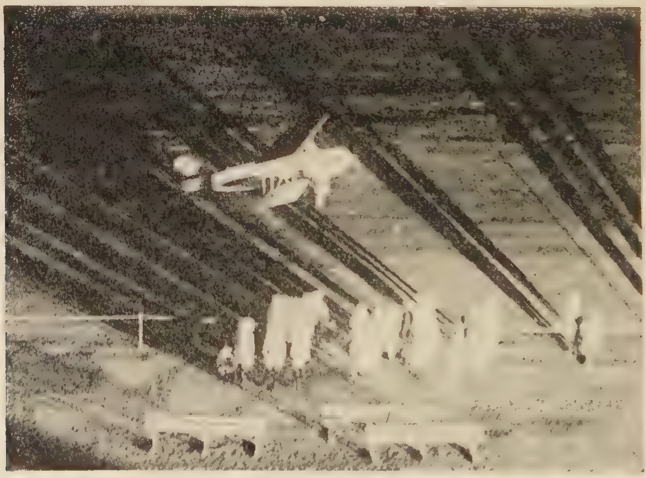

Fig. 9.—A night view at Oakland, Calif., Airport showing the powerful lighting system.

and as many machines are not yet equipped with brakes. So far as the space for landing is concerned, any airplane can usually be safely landed in a shorter space than it can be *safely* taken off from.

Side Slip Landings.

There are other types of landings which might be mentioned here, although it should not be necessary to resort to their use on any field which has been properly designed. The most important of these is the "side-slip" landing. This maneuver is used to effect a landing upon a field surrounded by obstacles. The pilot approaches the field at an altitude considerably higher than would be used in the case of a normal landing. He forces one wing down until the airplane begins to slip sideways and, when within about 20 to 50 feet of the surface, straightens out and finishes as when making a normal landing. This is much safer than it sounds, and in the case of very small fields it is probably safer than making a normal landing. Some pilots make quite a practice of side-slip landings, and they are frequently necessary when effecting a landing on some small, intermediate field. The method really amounts to using the braking effect of the side of the body to effect a very steep glide. On account of the large area of the sides of commercial airplane bodies, it seems possible that this form of landing may become frequently used in the case of mail or freight airplanes, although not at all desirable in the case of passenger carriers because of the mental effect upon nervous passengers. The "fish-tailing" landing is one in which the rudder is used to swing the tail around slightly, first to one side and then to the other, so that the side of the body offers additional resistance and serves to reduce the speed.

General Conditions to Be Considered in Selection of Site.

The more important questions to be considered in the choice of a field site are: size, altitude, orientation, types of aircraft to be used, surroundings, meteorological conditions including local sources of smoke or fog, type of soil and its surface, amount of grading and levelling required to make the site usable, transportation and other facilities to which brief reference was made in the preceding Chapter and which will be discussed fully in succeeding ones. The order in which these are given should not be taken to indicate their relative importance, as this will vary for each project. A number of additional questions will demand consideration in the arrangement of the field, but these points just mentioned include most of the important ones having some bearing upon selection of the site. In the case of seaplane bases or airship fields, some special requirements must be given consideration, and these will be discussed later under their respective heads.

Size of Plot and Types of Airplanes.

The question of size is closely tied up with the altitude above sea level, the types of machines, their performance characteristics and the class of the surrounding property. Heavily loaded commercial freight and passenger airplanes require a somewhat larger field than the lighter loaded and privately operated types. Hence a field from which the latter operate satisfactorily cannot be considered a criterion for other uses. The size of the plot desired will usually be fixed by the desirable length of landing areas or runways, which, as previously mentioned, should be from 2,500 to 3,000 feet for average conditions and a field located at an altitude not greatly in excess of sea level. Thus for a square field with diagonal runways a plot of about 2,000 by 2,000 feet (92 acres) will suffice, although increased area is always desirable, and a plot of slightly over 2,500 by 2,500 feet (144 acres) is to be preferred as it makes possible the highest government rating as to size. If the necessary area is not available for fields of these sizes, plots of 1,800 by 1,800 feet, or even 1,500 by 1,500 feet, can be used, but these smaller sizes are to be avoided wherever possible, as the close limits may result in accidents, and hence they are given poor ratings by the Department of Commerce. Obviously, the character of the surroundings will have an important bearing on field size and will be discussed later.

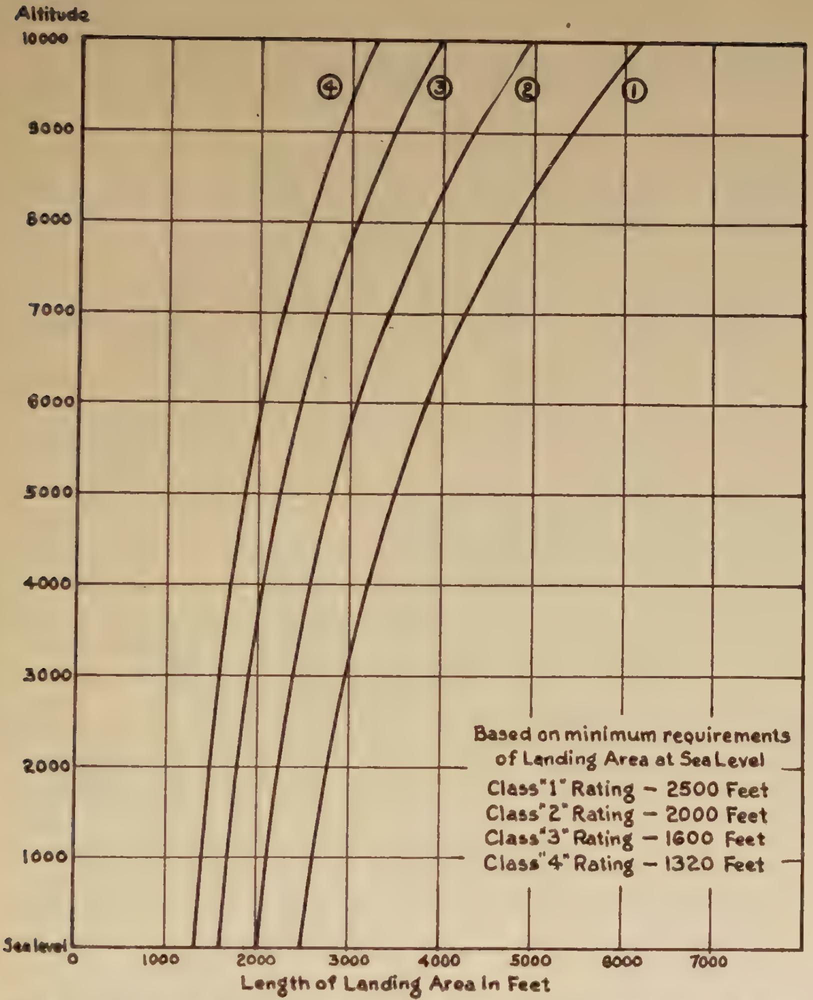

Fig. 10.—Increase in landing area, as required by Department of Commerce Regulations, for airports at altitudes above sea level.

Size of L and T Plots and Intermediate Fields.

A square or round plot is to be preferred, but where the field must be built in L or T shape the width of the legs of the L or T should not be less than about 1,000 feet. The length of these, of course, will be determined by the length of the landing areas or runways. Intermediate fields which are placed along an airway and intended to be used *only for emergency landings and for no other purpose* may be as small as 500 by 1,000 feet, although somewhat greater size is desirable even for this purpose. In cases where the altitude is considerably above sea level,—say more than about 1,000 feet,—all of the foregoing figures must be increased. This question of size of field for altitudes is so completely tied up with the type of airplane and its loading that the author believes it desirable to avoid generalities on this point wherever possible. Instead, he would suggest that the landing and take-off runs of the airplanes to be used be determined for the altitude of the field and that its size be increased in the proportion that these are increased over the sea-level performance. This is the best method of fixing the size of fields for high altitudes. However, if approximations *must* be made, some very valuable help can be obtained from the minimum requirements of the Department of Commerce for fields at altitudes above sea level and which are given in the accompanying diagrams, Figures 10 and 11.

The Question of Airplane Performance.

The matter of airplane performance, which has already been mentioned, has an important influence upon the required size of an airport and is a point to which study has been given both here and abroad. Wm. H. Miller, Research Engineer of the Curtiss Aeroplane & Motor Company, was among those who made an investigation of the question, and, upon the request of the author, Mr. Miller kindly summarized his findings as follows:

"The performance characteristics of an airplane which manifest the greatest effect upon take-off and landing are: (1) Stalling speed; (2) maximum angle of climb; (3) controllability at the stalling attitude. Although often omitted from consideration, the last item is one of the utmost importance, because the ability of the airplane to glide under control at its stalling attitude is absolutely essential if the size of the flying field is to be reduced to a minimum. As an airplane climbs after taking off it reaches a certain altitude at which it has just insufficient height to make a turn back into

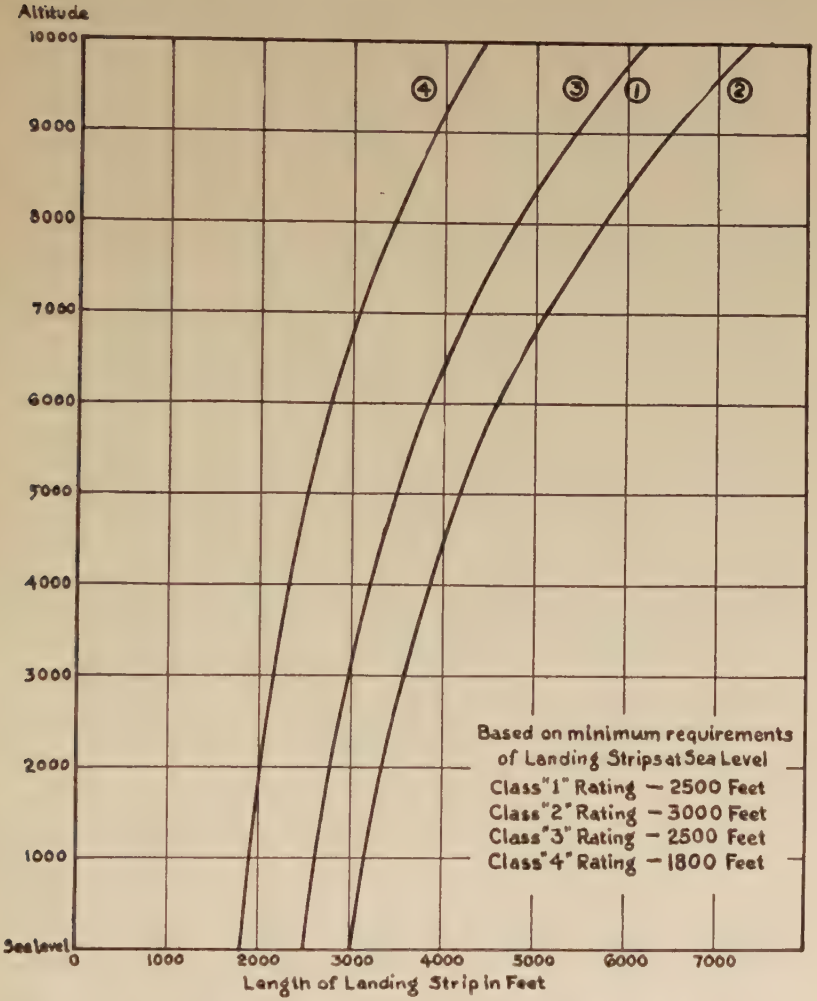

Fig. 11.—Increase in length of landing strips, as required by Department of Commerce Regulations, for airports at altitudes above sea level.

the field with the engine dead. Where safe descent is to be made possible in event of engine failure when taking off, a field must have its runways of sufficient length to enable a landing to be made from this point without turning. Hence the flying field must be of sufficient size to accommodate: (1) take-off; (2) climb to the critical height; (3) glide to the ground from this height; (4) landing run.

Length for Landing in Case of Engine Failure.

"On this basis, the length of run for conventional airplanes varies from 2,000 feet up to about 10,000 feet, depending upon the factors mentioned as influencing take-off and landing. In most cases these distances would require an area of prohibitive size. However, practical and theoretical considerations indicate that a single-engined airplane having a stalling speed of 50 miles an hour, a weight of 15 pounds per horsepower and which is equipped with wheel brakes can be safely operated from a flying field having 2,500- to 3,000-foot runways, considering even the possibility of engine failure at the critical height. For fields at altitudes considerably above sea level the dimensions may also be kept reasonably close to these values by employing airplanes of low wing loading and possibly supercharged engines. For multiple-engined airplanes (where level flight or an extended glide could be maintained in case of failure of one engine) these figures would be considerably reduced.

Glauert's Proposed Rotary Take-Off.

"With the object of decreasing the size of flying field necessary for operation of heavily loaded single-engined airplanes in safety, H. Glauert of the Royal Aircraft Establishment has suggested *the use of the rotary take-off and landing. With this arrangement the airplane would always make a climbing turn upon taking off and would make a similar descent if engine failure occurred at a height too low to permit a complete turn back to the field. Calculation showed that this system would considerably reduce the size of field required for safe operation of very heavily loaded single-engined airplanes. In any case the flying field of the future may be proportioned in accordance with the reduction of stalling speed, use of brakes and improvement in control at stalling speed for the airplanes which are to predominate at each airport."

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* Reports and Memoranda #996, Aeronautical Research Committee, British Air Ministry.

Wind Direction and Orientation.

The site of any field should be orientated, where choice is possible, so that the higher prevailing winds parallel some of the take-off areas or runways the greatest part of the time. In considering this, the importance of the direction of any wind may be considered to vary directly with its frequency and with the square of its speed. Winds of low velocity, say 10 miles per hour or less, may be completely neglected if others of higher velocity happen even infrequently, as the latter will become the governing condition. Many cases will be found where the wind variation is so general that little or no difference is made by the orientation. In this case the question may be dropped from further consideration and other angles taken up.

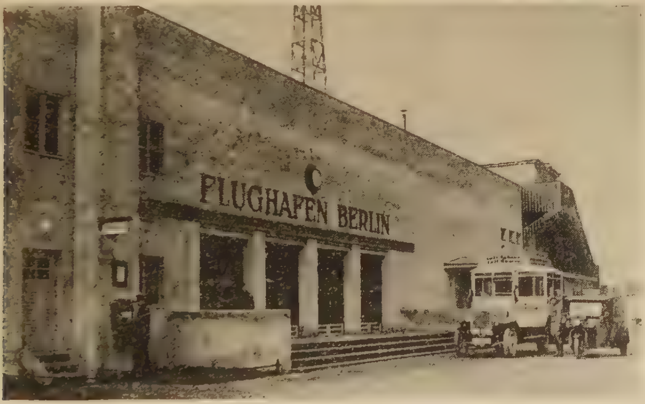

Fig. 12.—Entrance to the passenger waiting room at Tempelhof Field, Berlin.

Surroundings and Approaches.

The surroundings of the site should be, so far as possible, free from large or high buildings, tall trees, groups of trees, chimneys, radio or transmission towers and similar obstructions likely to interfere with air currents or with the approach of airplanes to the field. It is well to note that groups of trees are frequent causes of troublesome air currents, and their arrangement should be carefully studied by some airport engineer or other person familiar with the peculiarities of these air currents. Where possible the offending trees should be removed when the airport is being constructed. Consideration must be given to the possibility of the territory surrounding the field becoming built up in the future. An effort should be made at the time of purchase to restrict this adjacent property against the erection of structures exceeding about ten per cent of their distance from the field property line. The territory just behind the field buildings could be covered by less stringent restrictions.

Meteorological Conditions and Their Effect.

Among the important elements to be considered in the primary selection of an airport site are the meteorological conditions to be expected. While this whole question will be taken up in the Chapter on meteorology, a few notes will be made here. This investigation should cover not only the field site itself but also the air routes leading into it. Weather Bureau records and personnel should be consulted so that complete information on this subject may be obtained. If the observation station of the Weather Bureau is located at some distance from the contemplated site, it may be desirable to take special observations at the site over a period of time sufficient to warrant their use in modifying the Weather Bureau observations. The territory surrounding the field site should be, so far as possible for the locality in general, free from fog and very gusty winds. Freedom from high winds is also important, but not so important as the first-mentioned items. Precipitation of rain should be low or evenly distributed throughout the year, but there is seldom, if ever, any choice in this regard.

Effect of Snow and of Wind Direction.

Freedom from snow is also desirable, but here again there is not likely to be much choice in a given locality. Snow somewhat reduces the carrying capacity of airplanes by lodging on their wings and increasing their weight. It does not directly interfere with taking off or landing *if equipment suitable for this purpose is used.* However, the melting of a heavy snowfall will greatly soften the surface of the field and will confine take-off and landing to prepared runways. It is from this point of view that snow is most objectionable. The direction and velocity of prevailing winds should be obtained, as this information will be required in working out the proper arrangement of the buildings, runways, etc., as will be shown in the subsequent Chapter already referred to. Effort should be made to have the property lines laid out so that the higher velocity prevailing winds parallel the take-off and landing areas or runways, as suggested in a previous paragraph. In using the data obtained from the Weather Bureau it should be remembered that these are general for the locality. The possibility of their local modification, previously referred to, should be considered. Hills, groups of trees, large buildings, areas of water are some possible causes of such modification affecting wind currents and visibility.

Soil, Surface and Drainage.

Preference, where any is possible, should be given to a soil which drains naturally, but which is also suited to the raising of a close growth of tough all-year grass. These requirements will sometimes conflict. Where drainage is naturally poor the provision of some system of artificial drainage, particularly for the landing and take-off areas or runways, should be considered necessary. Indeed, only in exceptionally good cases can the provision for artificial drainage of these portions be omitted. No matter how well the soil may drain under normal conditions, trouble is to be expected during the end-of-winter thaw and the spring rain periods unless the landing and take-off areas or runways are exceptionally well drained. The question of the actual field drainage system calls for consideration by a field drainage engineer. A local builder of race tracks, golf courses, athletic fields, etc., should be able to render much help in this regard through his being already familiar with the local soil and conditions. Much can be accomplished with the use of some good common sense and a few textbook figures, but there is always the danger of the system thus planned being unnecessarily expensive or ineffective. Further reference will be made later to this question of drainage, and a comprehensive discussion of the problem will be found in any of the several textboks on the subject.

Grading and Levelling.

The field site should be tolerably free from mounds, ditches and other surface irregularities. It should be either entirely clear or should be capable of being cleared of any brush or heavy growths without incurring excessive cost. The general grade should be level, preferably to within about one per cent and in no case should it greatly exceed about two per cent. Department of Commerce requirements for rating of airports fix a maximum of 2½ per cent. Where any part of the site, and particularly the landing and take-off areas or runways, exceeds this latter figure it should be regraded to within the limit. When construction is under way more importance will have to be attached to grading of these portions than to grading of other parts of the field. Similarly, more importance should also be attached to levelling of mounds and filling in of hollows and ditches than to the general regrading of the field. Ditches located close to the outer limits of the field are of lesser importance and might frequently be regarded as quite tolerable. Where open ditches are to be used for drainage—a practice not to be recommended—these must be located very close to the field line and must not be carried across the line of the landing and take-off areas without bridging or carrying in pipe.

Transportation and Other Facilities.

In all cases the site should be readily accessible by a good road and preferably by a main highway. In accordance with the extent to which the field is to be developed, the following facilities should also be available: Railroad, telephone, water supply, electric power, and, if the railroad is not a passenger line, either trolley cars, buses or some other means of passenger transport should be available. The order in which these are given does not indicate their relative importance; this will vary according to the use to which the airport is to be put and the extent of its development. If it is to be used for commercial purposes, the site should be as near the city in *travelling time* as the ground cost will permit. If some distance out from the city which it is to serve, its usefulness may be greatly curtailed thereby. In the case of passenger traffic, the travelling time becomes of more vital importance than it is in the case of express package traffic. It is well to keep in mind that proximity to an express station on a railroad or to an express highway makes a distant airport easier and quicker to reach than one closer to the city. The ideal location for a passenger traffic field would be close to the station on a railroad with frequent and rapid service to the center of the city. However, proximity to a good highway permitting fast motor-bus service is almost equally good. This question of transportation will become a most important factor in the later development of passenger traffic, even if the field is to be used only for private and miscellaneous civil flying at the start.

Faults of the "Point" System of Site Selection.

In an effort to create some system by which the varying characteristics of several sites may be balanced for purposes of comparison, some engineers have adopted a system of grading these characteristics by points or percentage. In the development of this system, a maximum number of "points" or a percentage is assigned to each important characteristic of flying-field sites. Each site is then studied in detail and points assigned to it in accordance with its excellence (or otherwise) from the viewpoints of size, surroundings, drainage, distance from city, grading required and every other feature. The points assigned to each site are then totalled on the theory that the site showing the highest number of points is the best

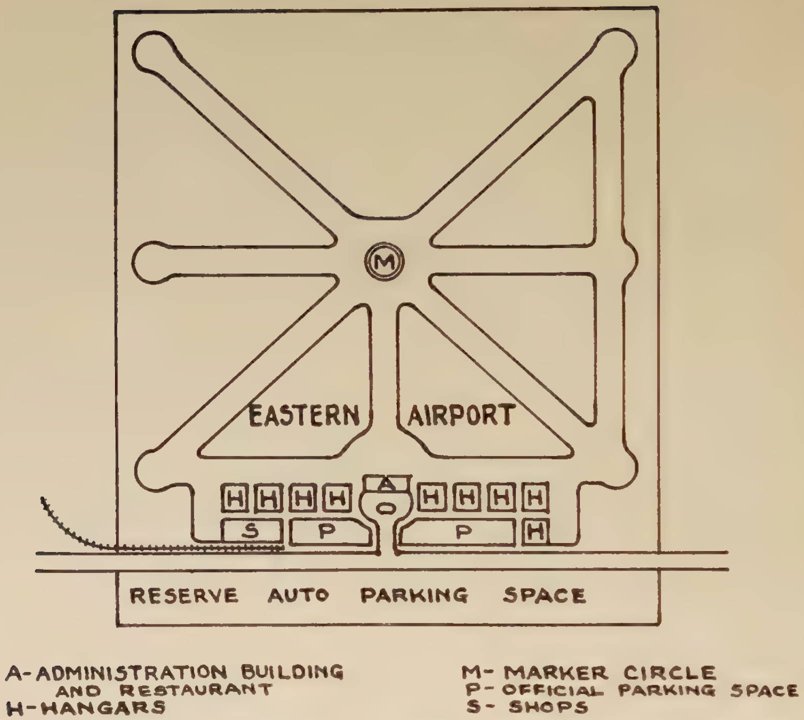
M
EASTERN
AIRPORT
H H H H
A
H H H H
S
P
P
H
RESERVE AUTO PARKING SPACE
A-ADMINISTRATION BUILDING AND RESTAURANT
H-HANGARS
M- MARKER CIRCLE
P- OFFICIAL PARKING SPACE
S- SHOPS

Fig. 13.—Airport development of a square plot with provision for auto parking on adjacent property.

all-around. This system is a very dangerous one for inexperienced engineers to apply. For example, suppose a total allowance of 20 per cent is arbitrarily fixed as the maximum allotted for size. One field might be excellent in every other characteristic, but so small as to be rated only two per cent on size. By totalling all of the other points, this site might appear as "82 per cent perfect" and yet be so small that some other site would be infinitely preferable. In short, this system has a very limited value and is capable of application only to sites that are nearly comparable. Even then it gives useful information only when applied by experienced airport engineers.

CHAPTER III

PLANNING THE FIELD LAYOUT*

Arrangement of the Airport.

Many airports in the past have been very much like Topsy—they "jes' growed." The arrangement of some older fields often inspires a thought that buildings were placed by erecting them wherever the local truckman happened to dump his loads of lumber. Certainly, the lack of intelligent planning gave no better results. No matter how modest may be the first construction work, the plans of an airport should make provision for future hangars, shops, garages, field office, gasoline and oil storage, roads, runways, identification marking, water supply, telephone connection, electric power lines, surface drainage (where necessary) and for future expansion with the object of obtaining a good rating by the Department of Commerce. While many of the facilities will not be installed at once, they should each be considered in the original plans. Only in this way can the airport provide a logical arrangement and obtain a good rating when it is fully developed. The additional cost of this forethought and consideration is negligible, while neglect might prove expensive later.

Plans Suitable for Square Plots.

It has been found that the arrangement of an airport depends upon many local considerations and that no one plan can be set up as an ideal for all cases. In Figure 13 is shown a good arrangement for a square plot, in the development of which liberal allowance has been made for parking of automobiles on adjacent property. A plan

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* Including some portions of a paper on this subject presented by the author before the International Civil Aeronautics Conference at Washington, D. C., December, 1928.

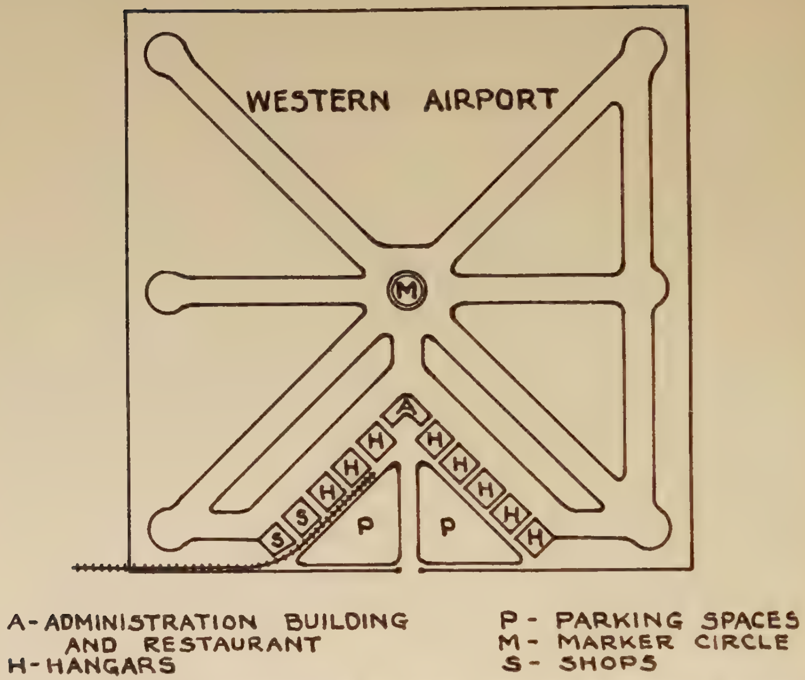


Fig. 14.—Airport development of a square plot with provision for auto parking behind hangars.

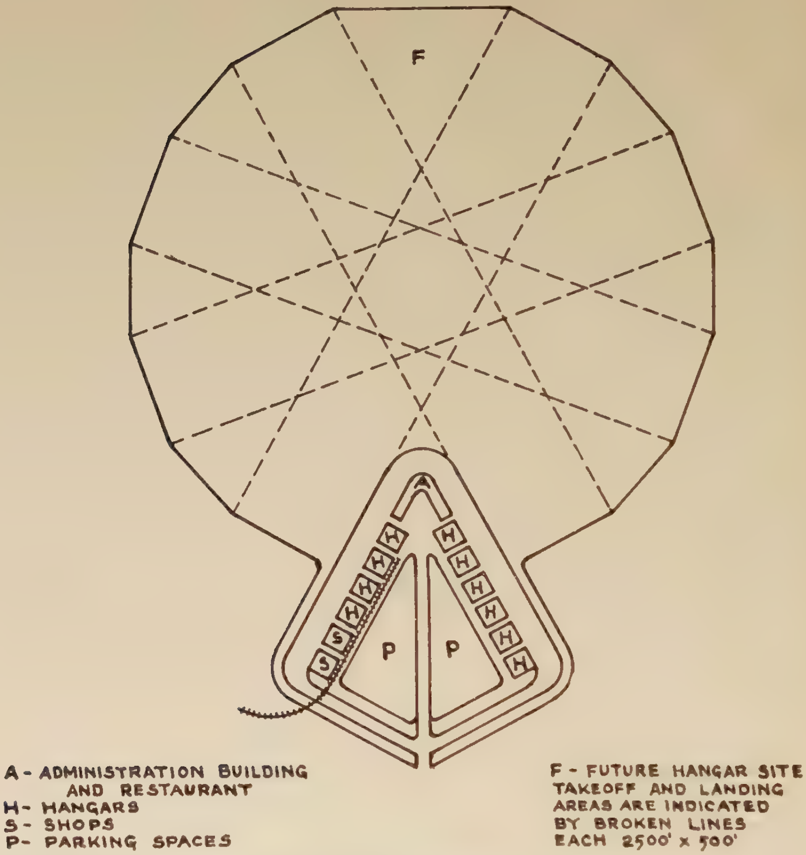
of this type permits holding of flying meets attracting very large crowds, but it may require more area than is conveniently avaliable. Figure 14 shows an alternate plan, also for a square plot, in which the buildings have been arranged to provide some parking space on the main plot itself. In some cases this arrangement may be preferable to the previous one, but care must be taken that the buildings are not carried so far out on the flying field as to constitute obstructions.

The Nearest Approach to an "Ideal" Plan.

A very different arrangement is shown in Figure 15 based upon some foreign proposals. In this plan the take-off and landing areas have been first plotted on top of each other on the sheet. The buildings have then been grouped within the angle of least frequent take-off. This plan has many advantages where it can be applied, and it represents a praiseworthy effort to develop a thoroughly "ideal" arrangement. However, it makes very limited provision for parking of automobiles when flying meets are being held. Furthermore, it usually becomes incapable of full application where any obstructions exist on the surrounding property. In the development of an airport layout, serious consideration must be given to surrounding obstructions, as these affect the arrangement of the landing and take-off areas. As this condition generaly exists at a site, the principle of "least frequent take-off" can seldom be applied without modification, but it should always be kept in mind by the designer.

Location of Landing and Take-Off Areas.

The design of any airport should begin with an effort to locate several landing and take-off areas of about 500 to 2,500 feet and arranged to suit both the surroundings of the site and the prevailing winds. In addition, it is very desirable to provide one longer strip of about 500 by 3,000 feet for use in taking off heavily loaded airplanes in still air. The direction of this latter strip is not affected by wind direction, and hence it may be placed mainly with regard to the field and its surroundings. Furthermore, as it is intended for use in still air, it is not essential that it permit take-off in both directions. At most sites the variation of wind direction throughout the year will make it advisable to provide for take-off and landing from almost any point of the Compass. Hence it is *usually* desirable that the landing strips be arranged to permit take-off under any of these conditions without exceeding an angle of about 20 degrees to the wind. The arrangement of these strips has an important bearing upon the ratings granted by the Department of Commerce, and to get the best rating it is necessary to provide for take-off in eight directions, with the angles between adjacent directions not less than 40 degrees.


F
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A - ADMINISTRATION BUILDING AND RESTAURANT
H - HANGARS
S - SHOPS
P - PARKING SPACES
F - FUTURE HANGAR SITE
TAKEOFF AND LANDING AREAS ARE INDICATED BY BROKEN LINES EACH 2500' x 500'

Fig. 15.—Arrangement of an airport having all buildings grouped within the angle of least frequent takeoff.

Considering the Obstructions.

In arranging these take-off and landing areas, consideration must be given not merely to wind direction but also to the freedom from obstructions (either inside or outside of the property) at their ends. In considering obstructions, it should be assumed that these render useless for take-off and landing the adjacent part of the area for a distance of eight or ten times their height. The Department of Commerce requirements for rating place the absolute limit at seven times the height, but it is advisable to allow more when possible. An effort should be made to have suitable zoning regulations adopted by the towns involved, so that the airport take-off and landing areas are protected against future interference. It will be found the local interests are more willing to cooperate if the regulations asked for are modelled after those already in effect in residential areas as regards height, setback and smoke nuisance. In placing take-off areas, some consideration should be given also to the possibility of effecting a landing in case of engine failure immediately after taking off. For this reason surrounding obstructions may be objectionable even if within the above-mentioned limit. Unless the soil drains very well the most-used portions of the landing and take-off areas should be artificially surfaced, and this point will be taken up in detail in a later Chapter. The artificially surfaced area, usually referred to as a "runway," should generally be at about 100 feet wide and 2,000 feet long. Preference should be given to materials of construction which are the least liable to give rise to clouds of dust after some time in use.

Location of Buildings.

In general, the buildings and any other obstructions to flying should be grouped together. The administration, passenger and pilots' buildings should be near each other, in a central position within the whole building group, and should be provided with space for parking of cars. In the design of fields for the better class of flying clubs, hangars and shops should be well separated from the club house and any athletic grounds. It is advisable to locate all buildings, towers, etc., within the angle of least frequent take-off where practicable. However, it is also essential that the buildings be located adjacent to a road so that it becomes unnecessary for automobiles or pedestrians to cross the flying field area. These two considerations must be balanced against each other in planning the airport, and, in some cases, it may become desirable to construct a new roadway. Some consideration may also be given to the roadway traffic and its effect upon the business attracted to the airport by proximity of the buildings and activities to passing automobile traffic. Within the group, the individual buildings should be liberally spaced for the purpose of reducing the risk of fire spreading. Fire hazard is usually serious at airports, and the area available for buildings seldom makes it necessary to place these close together.

Hangar Arrangement.

Hangars may be arranged with doors at one end or side directly facing the field or they may be provided with doors at each end to facilitate removal of airplanes. In the latter case they should be grouped in pairs with their doors facing each other to permit the use of a single concrete "apron" by adjacent buildings. In the colder climates of the northern hemisphere, if hangars are not heated and where other conditions permit, some preference might be given to a southern exposure, as this protects them somewhat from the cold north winds and makes conditions less uncomfortable for the mechanic in winter. In cases where the floors are of dirt or cinders it also has the additional advantage of allowing the sun to shine in through the main door and thus help to keep this floor dry. However, concrete is the most desirable type of hangar floor and should always be used when possible. The hangar layout should be sufficiently elastic to permit some variation in the types of buildings without destroying the general arrangement of the group. In the Chapter on Buildings such questions as size and type of construction will be taken up in detail.

Shop Buildings and Gasoline Storage.

No rule can be formulated for the relation between hangar, garage and shop floor space, as this varies so greatly for each project. In most civil airports a part of each of the hangars may be used for shop purposes at first and the erection of a special shop building may thus be postponed. In the case of airports which are the scene of extensive activity or used by large air transport firms this may not apply. An excellent method of providing adequate shop space without utilizing hangar area is that of constructing a lean-to against each of the hangars. When a shop building is provided it should be located adjacent to the hangars, forming part of the hangar group. All buildings should be connected by suitable walks and roadways developed in the original plan, with due regard to traffic. Gasoline storage systems of the underground type should be available to the flying field, hangars, shops and to automobiles. Further reference will be made to these in a later Chapter.

Office and Passenger Buildings.

The field manager's office should be so placed that it overlooks the field, and where a control tower is provided it should be on the roof of this building. The office building, passenger waiting rooms and pilots' headquarters should be closely grouped and preferably adjacent to the space allotted for parking of automobiles. In some cases these buildings are combined into one general building, often rather improperly called the "administration building," although "station building" would be a more appropriate name. In planning the arrangement of the office, passengers' and pilots' buildings (or a general-purpose station building), it is advisable to provide a paved driveway somewhat after the type used in country club plans and connecting these with the main highway. No matter what other provisions are made for parking, some space should be provided for limited parking near these buildings. It is advisable to designate, for use as a taxicab stand, an area located close to these central buildings. A suitable area, railed off from the flying field, should also be provided near the passenger buildings for the use of visitors watching activities on the field. Entrance gates should be arranged leading from this area to the field for the use of "hopping" passengers. At airports where flying meets are to be held, a grandstand may also be necessary.

Provision for Future Large Hangars.

While the buildings may be of substantially uniform size and type at first, those added later may be very different in shape and area. Thus, if some effort is made to anticipate the possible variations in future buildings, trouble may be avoided at some later date, and the space will be capable of utilization to better advantage as the building area becomes crowded with structures. With this thought in mind, the author made a study of existing types and sizes of hangar and shop buildings and found that a plot of about 200 by 200 feet would accommodate itself better to varying buildings and arrangements than a smaller plot. This plot also has the advantage of being practically a standard city block and of permitting the erection of ultimate buildings of 200 by 200 feet should conditions ever warrant this size. As the largest airplane built up to date was only some 131 feet wide, it will be noted that this future

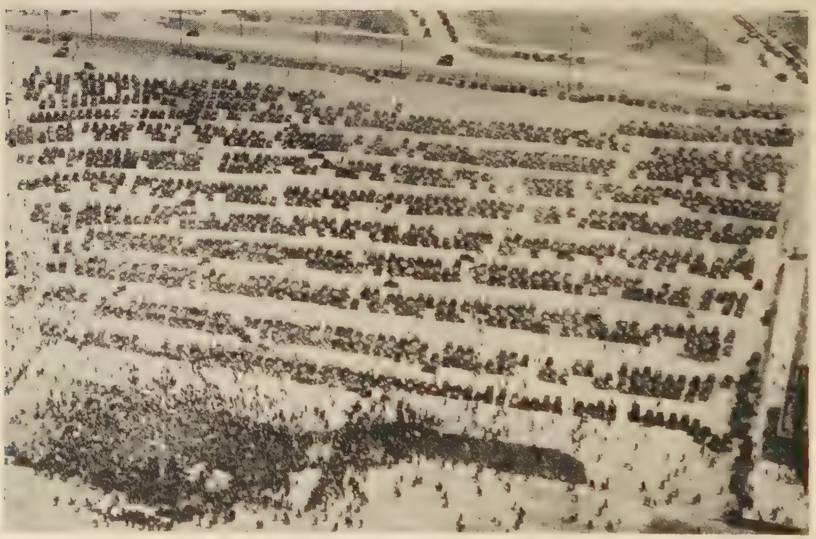

Fig. 16.—Aerial view of auto parking area at Cleveland Airport upon arrival of the German Transatlantic flyers on their tour of the United States. (Photo, Aerial Surveys Inc.)

building would provide for considerable expansion in airplane size. Where space considerations permit, some thought should be given to division of the building area into plots which could be utilized at first for groups of smaller buildings, while making provision for the erection of very large buildings if they become necessary in the future.

Connecting Hangars With Flying Field and Preparing Field.

Where any reasonable amount of flying is to be done, an area from the hangars to the flying field should be surfaced sufficiently to facilitate running airplanes out. The width of this portion will vary according to local conditions, but the strip should be at least 50 feet wide and located so that an airplane 100 by 150 feet wide can be rolled along it without touching the buildings. The flying field itself should be well drained, and, where natural drainage cannot be relied upon through the year, an artificial drainage system should be installed. On all parts of the field which are not covered by buildings, roads, surfaced runways, or such, a heavy growth of tough all-year grass should be raised in order to bind the soil. The kind of grass required will naturally vary according to the type of soil, and it is most advisable to consult some reliable seed specialists who will sample the soil, study the existing growths and recommend a suitable mixture. The question of clearing the site, draining and preparing for sod will be taken up in detail in subsequent Chapters.

Roadways and Railroad Tracks.

Roadways should be provided to connect each of the buildings with the main road entrance and with each other. The arrangement should be reasonably comprehensive so that drivers will use these roadways in preference to driving over the sod with resultant damage to the field. It is advisable to regard even the one-way roads as double lane and to prepare the surface for a width of 16 to 18 feet. Where there is no possibility of vehicles having to pass each other, roadways may be considered as single lane and surfaced for a width of only 8 to 10 feet. It is very desirable to make some provision for driving of automobiles or trucks around the borders of the field at the more important airports, but this marginal path need not be a high-grade roadway. While an important advantage, a railroad spur into the airport is not considered of such vital importance as formerly, since airplanes are so frequently delivered by air nowadays. If a railroad spur is carried into the airport grounds, it should be run along the rear of the hangar, shop and other industrial buildings.

Airport Marking.

Markers for the guidance of pilots should be provided for in the plans, and the Department of Commerce rating regulations require installation of: (a) a field marker circle, (b) identification sign on field or building, (c) field or take-off and landing area boundary markers and (d) marking by means of small red flags of any area temporarily unsuited for landing. The field marker consists of a circle of 100 feet in diameter with a white or yellow band 4 feet wide around it and set flush with the field surface. This marker should be placed in about the center of the landing area, or where runways intersect, at the point of their intersection. In the case of a single runway (two-way field), it should be placed in the center of the runway. The identification sign, consisting of the name of the town, or the name of the town plus the name of the field, may be constructed in the surface of the field or may be painted in white or yellow on a building and is required to be of such size that it is legible from an altitude of 2,000 feet. The field limits, or the outline of the landing area if not the same, is required to be marked by means of solid white or yellow circles, 4 feet in diameter, flush with the surface of the field and spaced not more than 300 feet apart. Where the field boundaries are lighted, these circles are required to be at the base of the boundary lights.

Construction of Markers.

Markers which are to be flush with the surface of the field should be so constructed that they will not become overgrown with grass in a short time. The sod and all of the top soil should be completely excavated in constructing the marker and the hole filled with broken stone, gravel, or other suitable material. This should be tamped or rolled down until firm. The material used should be clean and not too small in size lest it accumulate particles of top soil which would permit growth of grass on the marker. After construction, if the natural color of the filling does not give sufficient contrast to make the marker clearly visible, it should be whitewashed or painted to increase its visibility. In some cases a white marker may be desirable, while in others yellow may be preferable. Both summer and winter visibility conditions must be considered in making the choice of color. A temporary marker may be made by outlining it in lime wash after the method used in athletic-field and tennis-court marking. This method is very inexpensive at first, but requires constant maintenance and is therefore entirely unsuited for a permanent marker.

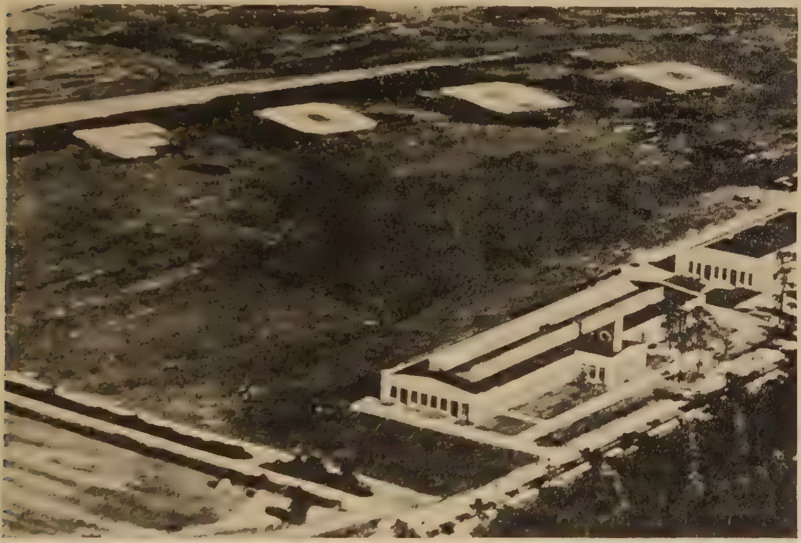

Fig. 17.—A portion of Ford Airport, Dearborn, Mich., showing the method of marking names on field surfaces.

Water Mains, Electric Power Supply and Obstructions.

If water mains are available within reasonable distance of the airport, lines should be extended into it and to each shop, hangar, garage and other such building. If no water line is available a well should be sunk, as a water supply is of much importance. Where electric power and telephone lines are available anywhere in the vicinity these also should be extended into the field, the power lines being carried into each and every building, while the telephone service is carried into the field office at least. Every effort should be made to confine the power lines poles to the rear of the field buildings and to limit their height. In any case where they pass the ends of the take-off and landing areas (even if outside of the field) they should be lowered sufficiently to eliminate danger of airplanes coming into contact with them. If radio equipment is to be installed, the preferable arrangement is to provide a remote-controlled station with the aerials distant at least ten times their height from the field. Where this cannot be done, they should be made as low as practicable and located behind or on top of the buildings so that all obstructions to flying are grouped together. No matter where located, they should be rendered as visible as possible both by day and night.

Obstruction Marking.

All dangerous obstructions, such as radio and transmission towers, flagstaffs, etc., should be painted in alternate stripes of black and white, or black and orange, to increase their visibility. This painting should be carried out in about the same manner as in railroad practice, the stripes being at an angle to the object upon which they appear and their width being chosen with regard to the general surroundings and looking towards the maximum degree of visibility. In most cases it will be necessary to erect a fence at least around part, if not completely around, the airport. In cases where the surrounding territory is not developed to any extent it may be practicable to reduce the amount of fencing, but in every case it is desirable to fence at least that portion adjacent to the public highway. If this portion is fenced, and the fence extended around the corner at each end of the property, entry by other than the regular gate will be greatly discouraged. All buildings and fences should be painted to make them plainly visible from the air, the system of angular alternate black and white, or black and orange, stripes (as suggested for towers) being the most effective means of accomplishing this result. If more artistic effect is desired, this might be obtained with practically no loss of visibility, but at slightly increased painting cost, by the substitution of a black and white checkerboard design in place of the angular stripes. All obstructions to flying should be marked with lights placed at their extreme points to warn flyers arriving after sundown. The question will be discussed at more length in a later Chapter when the question of night-flying equipment is taken up.

CHAPTER IV

CLEARANCE AND CONSTRUCTION OF FLYING FIELDS*

Clearing of Brush and Trees.

Once a site has been selected for an airport and the general arrangement worked out, it will usually be found necessary to do some clearing and grading. All tall grass, brush and trees should be cut down, and the debris should be either completely burned or removed from the site. It should never be buried, as rotting of the material would cause a low spot to form through sinking of the surface. It is particularly important that tree stumps be removed either by cutting well below the surface or by pulling out the entire stump, the latter method being preferable. Frequently it is more economical to use a 5-ton creeper tractor to pull down the entire tree, instead of cutting it and later removing the stump. All stones and boulders should be cleared from the surface and removed or buried.

Grading of Site.

The grading should be planned so that the smallest amount of material is moved the shortest distance. Considerable preference should be given to movements of soil which are sufficiently short to permit use of tractors or drag buckets, instead of calling for loading on trucks, as the latter method is less economical. If filling is necessary and there is any possibility of using the hydraulic system, this will always be found much more economical for any reasonable volume of fill. Indeed, the cost of filling by any other method is usually prohibitive if any large volume is involved. If hydraulic fill is used and there is some choice of material available, pref-

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* Prepared with the cooperation of F. W. Lewis, Lewis & Valentine Golf Course Co., Inc.

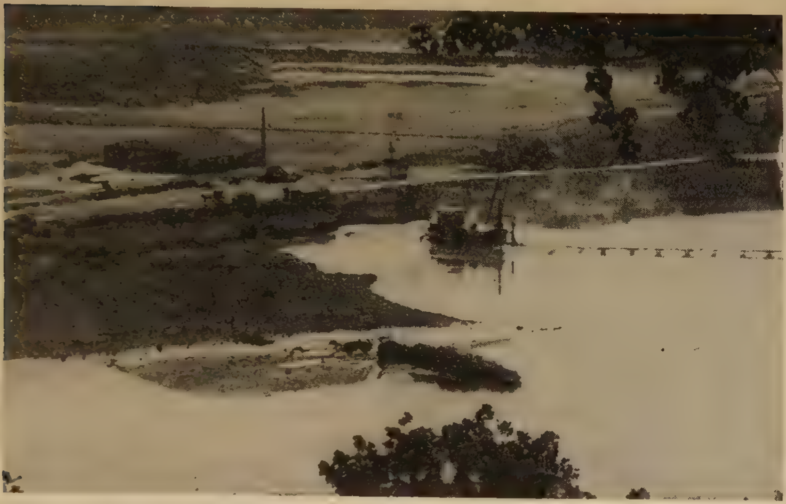

Fig. 18.—A dredge at work on airport construction, St. Paul, Minn.

erence should be given to the use of sand or gravel as against the finer-texture materials of which river-bed *mud* is composed.

Use of the Soil.

In cases where the grading consists of levelling mounds and filling in hollows with the surplus soil, great care should be taken to avoid burying the topsoil with the subsoil. Contractors are prone to carelessness in this regard and require almost constant supervision. The topsoil should first be removed and piled to one side to remain there until the operation of levelling is completed. After this it should be redistributed evenly over the levelled area. A depth of at least six inches of good topsoil is necessary, and more is desirable if a good growth of turf is expected. It is very much more economical to conserve this soil (if already on the site) than it is to attempt to rectify carelessness later. When filling of hollows is being carried out the contractor should never be permitted to use topsoil for this purpose as, otherwise, soft and muddy holes are very liable to result in wet weather. For the same reason it is not advisable to allow a really excessive thickness of topsoil to become accumulated on any part of the site. Six to twelve inches is the most desirable range.

Preparing for Turf.

Having cleared the site and levelled the uneven portions, the next step should be to prepare the soil for raising a growth of turf where this does not already exist. Where a fairly good turf already exists it is better to "let well enough alone" and to avoid plowing or harrowing this area. If the turf is rather thin, it may be improved (without destroying what already exists) by discing, with vertical cutters, sufficiently to permit seeding. It should then be lightly top dressed and rolled. As it takes a full year to get even a good start towards raising a firm turf, it is always poor practice to disturb any existing turf when this can be avoided. Where no turf exists or the present turf is not worth saving, the ground should first be plowed and then harrowed, preferably with a disc harrow, until thoroughly pulverized and a good seed bed is formed. It seems well to issue a word of caution about "city farmers." If this work is done by contractors who know nothing about farming, care must be taken that they do not plow too deeply in shallow soil or the result may be to pull up some of the subsoil and thoroughly mix it with the topsoil,—much to the disgust of the man who has the job of raising the grass.

Distributing the Seed.

Having thus prepared the soil, the seed should be distributed with a wheeled seeder and not by hand. The hand method is very wasteful and also results in uneven distribution of the grass. After seeding, the area should be rolled without wetting. The amount of seed to be distributed over each acre must be determined for each case, and the advice of an experienced grass specialist is very desirable. If a large area is to be seeded, his advice is more than

Fig. 19.—Madison, Wisconsin, airport at night.

desirable—it is essential. On the point of the amount of seed required, it might be noted that the flying-field condition is rather different from that of raising pasure or preparing golf greens or lawns. In general, the farmer uses much less seed, while golf greens may require somewhat more seed than advisable for flying-field preparation. Also, the parts of the area subject to heaviest use should be sown with considerably more seed than the balance of the area. In general, the amounts of seed will probably range from 50 to 150 pounds per acre, depending upon the fertility of the soil and the amount of use to which each part is to be put.

Selection of Grass Seed.

The kind of mixture used for seeding should be left to the judgment of some experienced grass expert who really understands the airport problem. The advice of other seedsmen will usually result in use of less suitable or much more expensive seed. As seed represents an important outlay where a large area has been prepared, its cost must be counted carefully. To properly recommend seed mixture it is advisable for the seed specialist to take samples of soil and, if convenient, to visit the site in person to study the existing native grasses and conditions at first hand. The following seeds, mixed *in proportions to suit the soil*, represent one good working basis of a seed mixture:

Canada Blue Grass
Fancy Kentucky Blue Grass
Fancy Red Top
Pacey's Perennial Ryegrass
Meadow Fescue
*Hard Fescue
*Sheeps Fescue
*Red Fescue

This is a fairly expensive seed mixture, but a very good one. The cost may be cut considerably by substituting Timothy grass for the four Fescues, but Timothy is a temporary grass, and it may therefore have to be reseeded slightly every second year. Portions of existing soils showing signs of sourness (indicated by a mossy growth) may require lime treatment, and salty pumped fill may require special seed. This, again, should be referred to the seed specialist.

Broome and Quack Grass.

In planning the seed mixture, consideration should be given also to creeping grasses, such as German or Rhode Island Bent and Broome grass, types which form a matted growth at the surface of the soil and which seem to be well adapted for airport use. Quack grass is another type which forms a rather similar growth, but its use is sometimes prohibited because of its characteristics of spreading and of killing off other growths. Hence it is classed by farmers as a weed. It is believed to have been tried with success on some fields. However, its use is certain to result in very strenuous objection on the part of adjacent property owners, and it therefore seems desirable to leave it out of consideration in most cases.

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* Soils having more than the usual proportion of sand require an increased amount of these. Bermuda grass has also been found to be well suited to sandy soils.

Oil Treatments of Exposed Soil Surfaces.

After an airport has been in use for some time it will no doubt be found that the continuous traffic makes it impossible to maintain turf on certain parts of the surface, particularly close to the hangars. This area should preferably be surfaced with concrete or macadam. However, with some types of soil, very effective binding and dust-laying results can be obtained by treatment with suitable "road oils." If the natural soil is not suitable for oil treatment, it may be practicable to make it suitable by distributing over the surface either clay or sand and gravel in accordance with the type of existing soil. A coarse-texture soil may require the addition of some clay, while a finer-texture soil may require the addition of sand and gravel to make oil treatment feasible. Oil treatments have been used at several airports and, while not as good as laying concrete or macadam, have been found a considerable improvement over the untreated

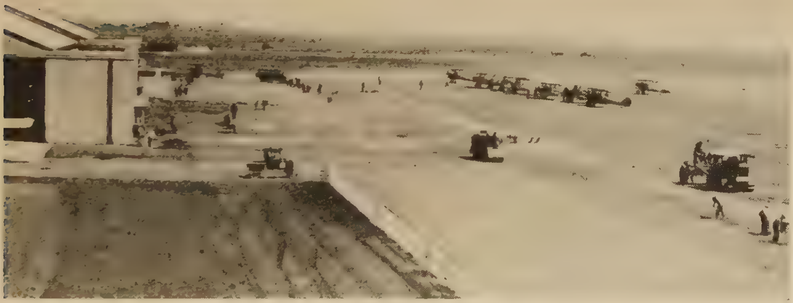

Fig. 20.—Spreading gravel in front of hangar No. 3 at Oakland, Calif. Airport.

soil. It must be remembered that oil treatment and grass cannot be reconciled, and choice must be taken of one or the other, as the oil treatment precludes any possibility of raising grass on the area treated. In general, the grass is to be preferred where the traffic permits it.

CHAPTER V

DRAINAGE OF FLYING FIELDS*

The Problem of Drainage.

"Drainage," someone remarked in conversation, "is rather a dry subject." The Greens Committee Chairman of the local Golf Club, or the flying field manager with sad and first-hand experience, might be pardoned for caustic comment on the accidental humor in these words. Be that as it may, the drainage of airport infields, roads and runways is an important problem and one which must be considered even before the site is finally decided upon. For the cost of drainage may, conceivably, be a deciding factor in the choice. In many cases a site may drain naturally to such an extent that complete artificial drainage is rendered unnecessary. In others the prohibitive cost of draining the whole area will restrict the amount of work even where complete drainage seems otherwise desirable. Perhaps the average condition will be represented in the case where the soil is fair or where prohibitive cost of a complete system requires a compromise to be struck by providing artificial subsurface drainage only for take-off and landing areas or runways and making no provision for the rest of the field. The roadways may be drained in practically all cases by means of open side drains which are very shallow and have wide, flat sides. Ordinary steep-sided trenches should never be used for road drainage unless hugging the edge of the field or some of the buildings. It should always be assumed that roads bordering on the infield may sometimes be crossed by airplanes being moved around the field. The side drains should therefore be shallow enough to make this crossing practicable.

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* Prepared with the cooperation of George E. Martin, Consulting Engineer, New Rochelle, N. Y.

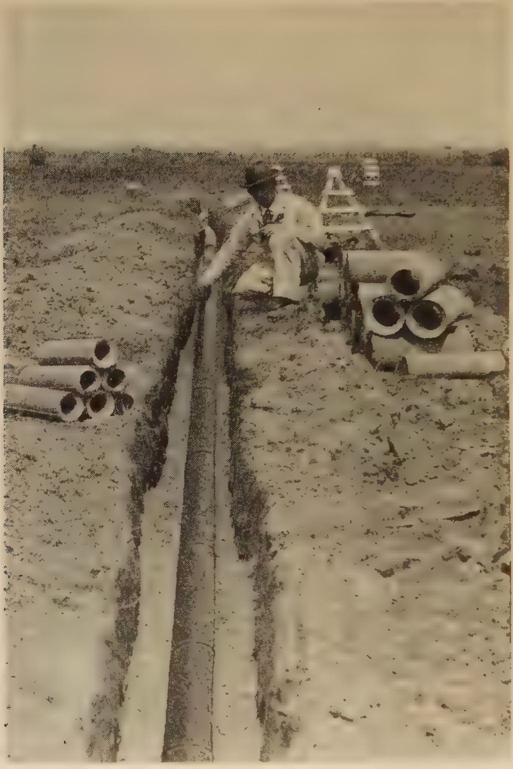

Fig. 21.—Laying "Poroswall" tile drains at Teterboro Airport, Hasbrouck Heights, N. J.

Drainage Surveys.

As a preliminary to consideration of any serious drainage problem, several drillings should be made at widely separted parts of the site. These should be of sufficient depth to reach a porous subsoil where such exists and, in any case, they should be at least 4 to 5 feet deep. The class of soil and its ability (if any) to absorb moisture being determined from these drillings, a decision can be made as to the extent to which artificial drainage must be carried. If it is found that a complete system is needed, systematic drillings should be taken across the field in each direction, the stations being spaced perhaps 200 to 400 feet apart. The information thus obtained will furnish data on the water flow and porosity of the subsoil which will be valuable in the drainage layout. It must be noted here that the layman, and very frequently the ordinary civil engineer, can learn little from these borings. This study *must* be made by an engineer who ranks as a specialist in field drainage. In many cases where artificial drainage is required, it will be found that it is needed only during the spring thaw and rainy seasons. Other cases will be met where the soil is so impervious to moisture as to necessitate complete surface drainage.

Type and Placing of Drains.

Drains may be of porous pipe, tile, broken stone, rubble, or any other conviently available material. Of these the porous pipe and tile drains are by far the most effective and no others should be considered. The depth of pipe or tile drains will depend upon the type of soil, distance between lines and the interval between heavy rainfalls, 2½ to 4 feet below the surface being about the average range. A fine-texture soil, such as clay, resists penetration by moisture more than do the coarser-texture soils, such as loam or soils containing considerable quantities of sand or gravel. Consequently, the drains should be placed nearer the surface for the former than for the latter. The distance between the lines of drains is governed by the same considerations, and the shallower the depth, the closer the drain lines must be placed. A spacing of 40 to 100 feet, or in exceptional cases 125 feet, will be found to be about the correct distance for satisfactory operation. The size of the drains and their grading should be such that they will carry off the maximum precipitation which may be expected during any 24 to 36 hours, giving due consideration to the tendency of heavy storms to surface-drain to the low areas.

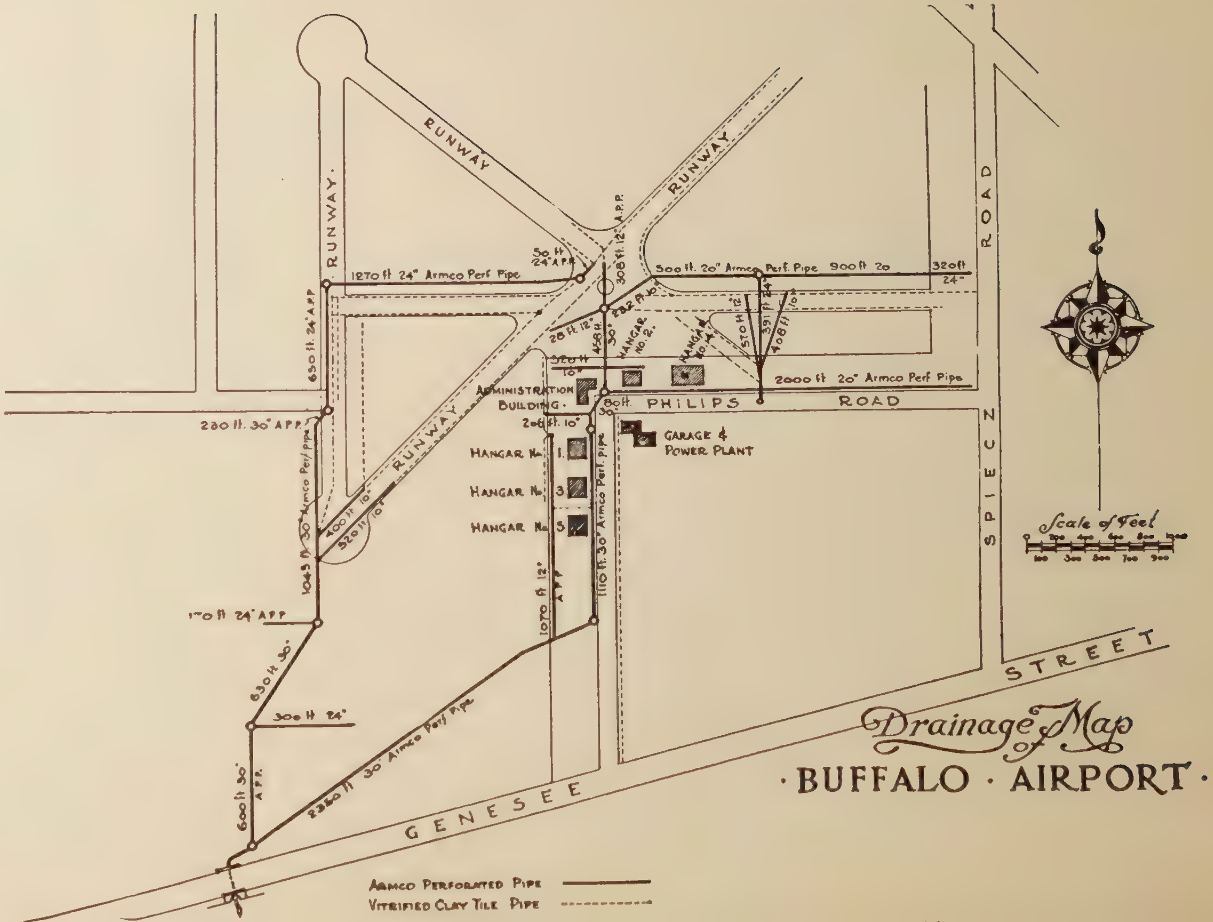

Fig. [illegible]. Plan of drainage system used at Buffalo, N. Y. Airport.

Runways and Type of Drains.

Where the surface is not level the fullest use should be made of the natural drainage when planning a system. Particular attention should be given to the drainage of the more central parts of the field, the parts in front of the hangars and to take-off and landing areas or runways. Where funds are limited and broken stone or rubble are readily available, these may have to be used in place of the pipe or tile, although not satisfactory. Broken-stone or rubble drains are constructed by trenching the field, filling the trenches with the stone or rubble and covering with either soil or fine gravel. In all cases where these filled-trench drains are used, the larger stones should be placed in the bottom of the trench and the sizes decreased to the smallest at the top. This will prevent or delay the filling up of the trench with silt. A plan of the drainage system should be kept by the airport management to facilitate correction of faulty drainage in future.

Disposal System.

The drainage system should be designed to discharge into a catch basin leading to any convenient stream or similar outlet. This catch basin is intended chiefly to trap silt and thus prevent choking up of the outlet after a time. It may be dispensed with if this danger appears remote. If the ground around the airport is flat and no outlet is available for discharge of the drainage, it may become necessary to construct a canal system around the field and located as close as possible to the property line. The drain outlets may then be arranged to discharge into this canal at various points and the water allowed to gradually seep away into the porous subsoil or it may be emptied by pumps as the case requires. In cases where the canal must be carried across take-off and landing areas, it should be bridged with timbers or carried in pipe.

CHAPTER VI

AIRPORT ROADS AND RUNWAYS*

Roadway Traffic Requirements.

In the design of any airport at least some roadway construction will be found necessary. The actual amount may vary from a few hundred feet to half a mile of road, and in comprehensive projects it may even exceed the latter figure. The funds available for construction of roadways at civil airports usually limit this work to a moderate cost, sometimes at the expense of increased maintenance costs. The traffic which these roads are required to carry is not as continuous as on a highway, but it includes loaded motor trucks as well as the lighter passenger cars, and these trucks will range from the smaller sizes up to about 5-ton capacity. To make matters worse, this 5-ton truck may be loaded above its rated capacity with airplane engines, gasoline or oil. As any highway engineer will agree, this is a most unfortunate combination. The infrequency of the traffic causes hesitation about constructing really substantial roads, yet, as one road builder put it, "your one truck is just as heavy as if several others were following." Then, to make matters worse, the airport road is often neglected once the construction is completed.

Basic Elements of Roadway Construction.

For the benefit of such readers as are not familiar with roadway construction, it seems well to begin with an elementary outline of the subject. Roadway construction must furnish a surface: (1) into which the wheels of vehicles will not sink appreciably in either dry or wet weather; (2) which does not become washed away in rainy weather; (3) which cannot be carried away by the wind in dry weather, and (4) which affords safe traction. Any surface that fulfills these requirements makes a suitable roadway. Unfortunately, the raw materials available for road building are seldom suitable for use alone. Sand (the coarsest texture soil), when wet, has a sufficiently hard surface to provide a fair roadway for light traffic. On the other hand, it loosens up and becomes almost impassible in dry weather. It is also liable to be carried away by wind in dry weather, or be washed away by heavy rains. Clay, the finest texture soil (and the other extreme in this range) provides a fair surface when dry, but it is so soft and slippery when wet that traction becomes impossible. The soils ranging between these two extremes partake of the characteristics of either or both in accordance with their texture. Consequently, either the use of foreign materials on the surface or redistribution of the existing materials is necessary to the construction of proper roadways. In addition, with practically all forms of construction, the center of the roadway must be somewhat raised or "crowned" to drain surplus water away and thus prevent puddling and consequent softening of the road. With the use of water-resistant materials, such as the bituminous compounds or concrete, the tendency to wash away is eliminated and the crown of the roadway may be decreased.

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* Prepared with the cooperation of John S. Crandell, Professor of Highway Engineering, University of Illinois.

Widths of Roadways.

The width of roadways should be arranged for two lanes of traffic, excepting where there is no possibility of vehicles passing each other on the road. If a single-lane roadway is constructed and then used as a double-lane road, the finished surface will become rapidly broken up at the edges where vehicles pass each other. Single-lane roadways should be graded over a width of 12 to 15 feet and double-lane roadways over a width of 25 to 30 feet, depending upon the quality of the finished surface. A well-bound surface, being little liable to wash away, does not require grading over great width. On the other hand, earth, sand and similar roadways which wash away rapidly must be graded over considerable width and well crowned to prevent their being washed out by the first heavy storm. The widths of the finished surface of roadways should be 8 to 10 feet for single lane and 16 to 18 feet for double lane. In the case of the poorer classes of surfacing, it is advisable to somewhat increase these figures.

Runway Traffic Requirements.

The purpose and use of airplane runways having been described in a preceding Chapter, there is no need of further comment here. All airports were formerly arranged without clearly defined and artificially surfaced runways. In these cases airplanes always took off from and landed upon any part of the field, using the grass-covered surface. With regular use even the most substantial turf breaks down and, at certain periods of the year, becomes thoroughly softened. Consequently, the past several years have seen a growing tendency to provide specially prepared runways, and this tendency will no doubt increase until their use becomes a universal practice. These runways must be designed to carry the load of airplanes landing on or taking off from their surface and, in general, should be capable of carrying such loads as the following without injury:

CUSTOMARY AIRPLANE TIRE LOADINGS

Tire size in inches.	Normal load in pounds.
14x3	600
26x4	750
28x4	1,000
30x5	1,600
32x6	2,200
36x8	4,000
44x10	6,000
54x12	9,000

Runway Construction.

Careful attention should be given to the type of construction used for the runways, although this point is often neglected. Most types of roadway construction are not suited for runway purposes because of their high cost or the manner of grading. Practical experience has shown the use of rolled cinders or slag to be a fairly satisfactory material for runway construction, excepting that, after extensive use, it gives rise to clouds of gritty dust which work harm to engine parts. A smooth, hard surface is very desirable to take off from, but has not yet become accepted as desirable to land on, even if the airplane is equipped with wheel brakes. Where runways are to be used for both landing and taking off (as customary) the surface must be adapted to either use. Very hard and smooth surfaces, such as obtained by the use of concrete, are not popular with pilots, who prefer a surface having some resiliency. Furthermore, if the airplane has no brakes, it will roll an excessive distance when landed on concrete. If the use of brakes becomes general, it seems probable that this condition may be modified and the use of concrete or other hard-surfaced runways may become more popular. Where concrete or other hard-surfaced runways are constructed, it seems desirable to parallel these with others of good sod. Where funds are limited it is usually better to devote them to the construction of a large area with cinders or slag rather than to construction of a very small area with concrete, macadam, or other hard-surfaced material. It should be noted here that cinders which are well rolled and oil treated develop a hard surface very similar to macadam.

Drainage of Runways.

Runways must be as nearly flat as possible, and it is in this respect that they differ most from roadways. Some crown is, of course, necessary for drainage, but this should be kept to the absolute minimum and it is recommended that the allowance be fixed at ¼ inch per foot of width. Where possible the runways should be drained by allowing the water to seep through the surface into the

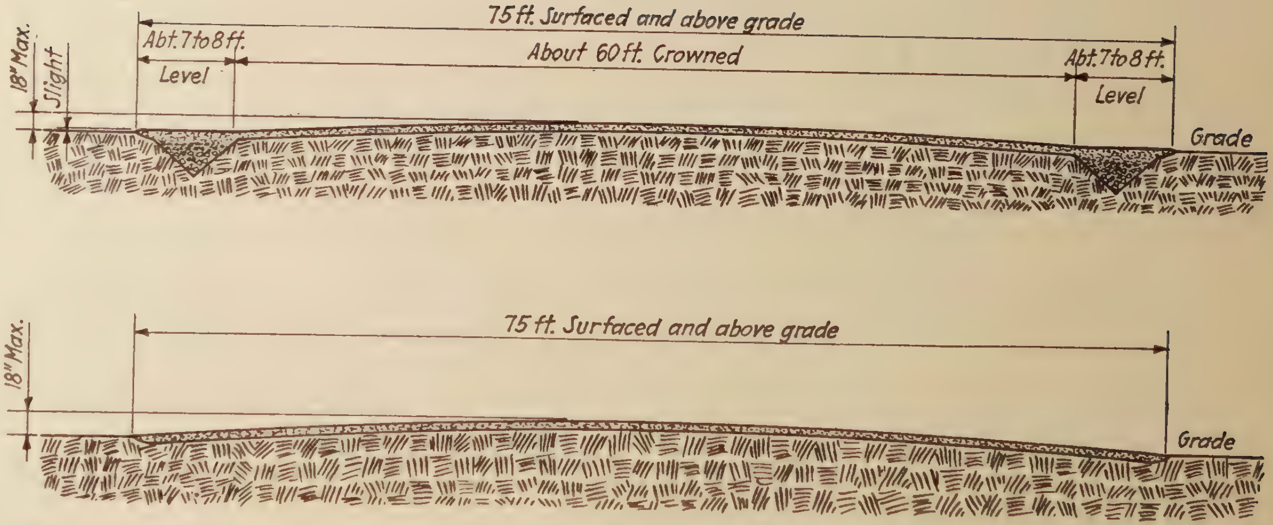


Fig. 23.—Types of runway construction for airports. Tile sub-drains should be used for these wherever possible.

soil below. This will be possible only in cases where the runway is not of concrete, tar macadam, or oil-treated materials, and where the soil is of coarser texture, such as sand, gravel, etc. Where artificial drainage is necessary, these drains should be constructed along the sides of or below the runways and should always be of the tile, perforated-pipe or of the stone-filled-trench type, which will be described later. As mentioned in a previous Chapter, open ditches should never be permitted either in the vicinity of the runways or on any part of the field over which airplanes are liable to run. A suitable type of construction, devised to meet the unusual requirements of runways, is illustrated in Figure 23. In this type either stone-filled trenches or pipe or tile drains may be used, the former being shown. Where filled trenches are used, the sizes of the stones must be graduated as described in the Chapter on drainage. Runway surfaces should be free from bumps and ridges and not even shoulders nor gutters may be used at their sides. All drainage must be obtained either by seepage through the runway surface into the soil or by means of sub-drains carried below the runways for this purpose.

Amount of Surfaced Runways.

The field arrangement will, most probably, call for take-off and landing strips extending from property line to property line with the exception of a short distance in the proximity of each fence. Often there is no necessity of artificially surfacing this entire length. However, future increase in use of the airport should be expected to make surfaced runways more necessary, and surfacing of a large portion of each take-off area may be considered an ultimate provision of the future. For immediate needs no surfacing may be absolutely necessary, or it may suffice to surface some 1,000 to 2,000 lineal feet of the portion most used and to a width of about 75 to 100 feet. In some cases, particularly where the soil is largely of gravel, the immediate need of surfacing may not be urgent, but this need will grow with increased traffic. Even in the best cases trouble will be experienced with unsurfaced areas used for take-off or landing during the spring thaw period. Surfaced runways are usually not worth building unless about 750 feet of area is surfaced to a width of about 50 feet. While this is a very small area to construct, it is better than none at all if conditions are bad.

Materials of Construction.

Either gravel, cinders, slag or broken stone will be available locally at a cost which justifies their use, and any of these materials may be regarded as suitable for airport roads and runways construction. A mixture of sand and clay is also worth considering where other materials are high in price, but this does not provide a good surface for heavy or continuous traffic. Excepting concrete, practically all types of road construction require the use of a binder to prevent loosening of the materials. Almost any liquid may be used as a binder, but some are particularly well adapted to this purpose. Rain is the cheapest binder, but it is also the most uncertain, as the water evaporates and leaves the surface dry and loose in hot weather. Loosening up of water-bound roadways in this manner can be greatly retarded by spreading calcium chloride over the surface. This salt, having an affinity for water, absorbs moisture from the air and keeps the roadway damp. It may be distributed either with an ordinary farm fertilizer distributor or in any other convenient manner and may be left to become mixed with the surface material naturally.

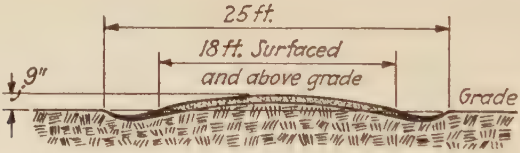


Fig. 24.—Cross section of gravel or cinder roadway.

Bituminous Binders.

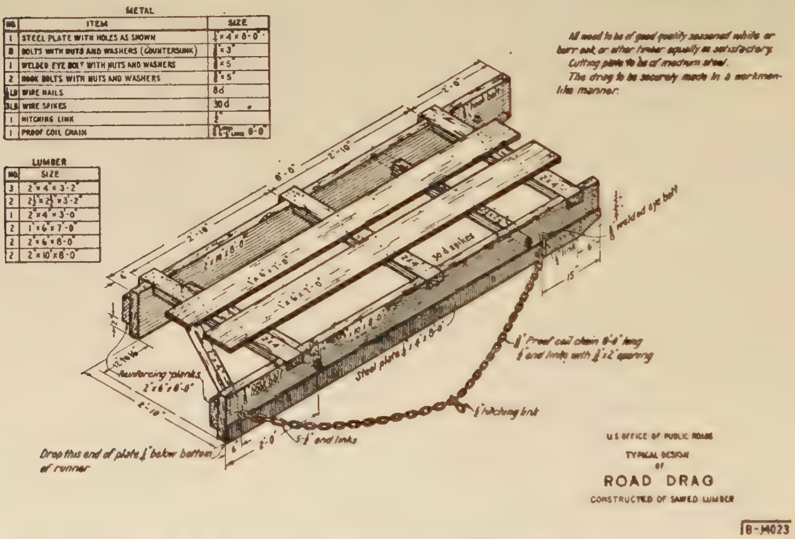
During the past few decades there has been a quite general adoption of bituminous materials or "road oils" (such as those marketed under the trade name of Tarvia) as binders. These compositions are undoubtedly the most satisfactory for this purpose and they can be used on practically any road requiring a binder, with the exception of such few as contain over 20 per cent of clay. When bituminous binders are used on the latter type of roadway surface, a slippery emulsion of the tar, clay and water forms during wet weather and interferes with traction. The grades of bituminous compositions used range from the liquids, which are sprayed over the surface like water, to the solids which are combined hot with stone or slag and rolled into place in the construction of macadam roads. Some materials require binders more than others. In this respect it is interesting to note that cinders and blast-furnace slag, because of their irregularities and interstices, tend to interlock when rolled. However, the binder prevents disintegration of the surface when the cinders or slag become pulverized under continued use. Hence it serves a very useful purpose, even here, in preventing or decreasing the troubles due to dust. This is an important point, as continued clouds of gritty dust are very hard on the working parts of the airplane engines.

Selection of Materials.

There is no one best type of construction for all airport roads and runways. That most suited to each case will depend upon several factors, being influenced largely by the cost of materials available locally and by the particular requirements of the airport considered. If gravel is obtained incidental to the grading of the field, or if it is available on the site, it may be found the most generally suitable material because of the extremely low cost. On the other hand, if gravel is not available at the site, while cinders or slag can be obtained cheaply, these may become the most convenient to use. Other materials throughout the list will be similarly affected. This is a matter upon which the local road builder should be consulted and perhaps estimates compiled for different materials.

Specifications.

The following brief descriptions cover several types of roadways and runways, one or the other of which will be found to meet the requirements of service and available materials. In addition to the types described, concrete and tar-bound macadam should also be given consideration. These represent the very highest grade of construction, but their cost is, naturally, also the highest. These outlines should not be regarded as complete construction specifications, but they are merely included to give some conceptions of the desirable construction in each case. A considerable number of minor variations might be made to suit local conditions. Figure 24 illustrates the appearance of the constructions in cross section. Usually it will be found most convenient to purchase a small gasoline farm tractor with a road-scraper attachment for use by the airport personnel in maintaining the roads and runways. If the volume of work does not justify this, a road drag might be constructed of



METAL

NO.	ITEM	SIZE
1	STEEL PLATE WITH HOLES AS SHOWN	½×4×8-0
8	BOLTS WITH NUTS AND WASHERS (COUNTERSUNK)	¾×3
1	WELDED EYE BOLT WITH NUTS AND WASHERS	¾×5
2	HOOK BOLTS WITH NUTS AND WASHERS	¾×5
1 LB	WIRE NAILS	8d
3 LB	WIRE SPIKES	30d
1	HITCHING LINK	½
1	PROOF COIL CHAIN	[illegible] 8-0

LUMBER

NO.	SIZE
3	2×4×3-2
2	2½×2½×3-2
1	2×4×3-0
2	1×6×7-0
2	2×6×8-0
2	2×10×8-0

All wood to be of good quality seasoned white or burr oak, or other timber equally as satisfactory.
Cutting plate to be of medium steel.
The drag to be securely made in a workmanlike manner.

2'-6"
2'-10"
6'-0"
2'-10"
hook bolt
30 d spikes
welded eye bolt
6"
15"
Proof coil chain 8'-0" long
end links with ½"x2" opening
Steel plate ½"x4"x8'-0"
hitching link
5-½" end links
Reinforcing planks 2"x6"x8'-0"
4'-10"
Drop this end of plate ½" below bottom of runner

U.S. OFFICE OF PUBLIC ROADS
TYPICAL DESIGN
OF
ROAD DRAG
CONSTRUCTED OF SAWED LUMBER

B-M023

Fig. 25.—Details of a road drag suitable for airport use where the work is so limited as not to justify other equipment. This drag may be handled behind a tractor, team of horses, or motor truck. (U. S. Bureau of Public Roads Drawing).

lumber somewhat after the type of the design recommended by the Bureau of Public Roads and shown in Figure 25. The motive power for hauling this type of drag might be either a horse or tractor or even a motor truck. The cost of providing a road drag is so slight that one should be furnished at every airport to facilitate maintenance of the roadways.

Dirt Road—Construction: Shape up soil with a road machine, over full width of roadway, to crown of about ¾ inch to the foot of width. This work should be done in such manner that the roadway and ditches are firmly compacted, free from high spots, hollows or patches of loose material and have appreciable shoulder. Finished road to be crowned about ¾ inch to the foot. *Comments:* The cheapest type of roadway. Should be used only where funds are too limited to permit any other and where neither heavy rains nor long dry periods are to be expected. Generally an unsatisfactory type.

Sand-Clay on Clay Soil—Construction: Plow soil over full width of roadway. Spread 4 to 6 inches of sand over width of about two feet more than desired finished surface; mix thoroughly with soil, starting dry and gradually wetting. The proportion of sand to be suited to the type of soil. Drag with wood drag, tractor attachment or road machine and crown about ¾ inch to foot. Spread about 1 inch of sand over surface and roll down. Finished road to be crowned about ¾ inch to the foot and to have appreciable shoulder. *Comments:* A cheap type of roadway which is fairly satisfactory for passenger-car traffic, excepting during the thaw, when it loosens up and must be redragged. It is not suited to heavy nor constant traffic. As described it is suited for use only on clay soil. The proportion of sand to be used in the mixture will depend upon the soil. As the State of North Carolina has had considerable experience with roads of this type, the State Engineer's office was consulted a few years ago. Mr. Hutchinson, assistant engineer, gave the proportion of sand as ranging from 10 per cent to about 25 per cent of the total, depending upon the class of clay.

Sand-Clay on Sandy Soil—Construction: Same as the sand-clay on clay base, excepting that clay is added instead of sand. Road finished in the same manner. *Comments:* Same as regards this type of road on clay base, except that it is used in this form on sandy soil.

Gravel Road—Construction: Shape up soil with a road machine, over full width of roadway, to a crown of about ½ to ¾ inch to the foot, the larger crown for the smaller gravels and vice versa. Spread over about two feet more than the desired width with coarse, screened gravel to a depth of 4 to 5 inches. Water and roll down until compacted. Spread over this first layer finer-screened gravel to a depth of 1½ to 2 inches. Roll, starting dry and gradually wetting and rolling alternately until the surface is solidly compacted. Finished road crown should be about ½ to ¾ inch to the foot, depending upon the coarseness of the gravel. Sides to have appreciable shoulder. *Comments:* A satisfactory type of roadway for most airport purposes and one which will hold up well under all but the heaviest traffic. Economical to use when gravel is obtainable at the site incidental to the levelling of the field. The grading of gravels as "coarse," "medium" or "fine" varies greatly. The following table represents the screen test of a typical New England gravel:

Passing through 1½-in. screen	100.00%
Passing through 1½-in. screen, retained on ¾-in. screen	11.7
Passing through ¾-in. screen, retained on ½-in. screen	6.7
Passing through ½-in. screen, retained on ¼-in. screen	16.9
Passing through ¼-in. screen, retained on ⅛-in. screen	17.3
Passing through ⅛-in. screen, retained on No. 50 screen	29.4
Passing through No. 50 screen	4.7
Clay content	13.3

Gravels of this class may be regarded as suitable (although the coarser they are, the better) and may spread in one layer or screened and spread in two layers as described above. Such gravels may be surface treated with bituminous binders to form an excellent roadway.

Cinder Road—Construction: Shape up soil with a road machine, over full width of roadway, to a crown of about ½ inch to the foot. Spread clean cinders over the desired finished width to a depth of about 8 to 9 inches when loose. Roll down until solidly compacted, the depth of the cinders after rolling being about 5 to 6 inches. Finished roadway to be crowned about ½ inch to the foot and to have appreciable shoulder. *Comments:* A satisfactory type of roadway for most airport uses and which will hold up well under fairly heavy traffic. Economical where cinders are cheaply obtainable, but prohibitive where they are expensive.

Macadam (Water-Bound) Roads—Construction: Shape up soil with a road machine, over full width of roadway, to a crown of about ¼ to ½ inch to the foot. Roll down well until solid, filling and puddling if necessary to obtain a firm, even surface free from hollows and loose spots. Spread large broken stone, about 2- to 3-inch sizes, evenly over the width of desired finished surface and roll down wet until solid and even surface about 4 inches thick is obtained. Spread medium broken stone, about 1-inch size, over the first layer; water and roll down until even surface with depth of about 2 inches is obtained. Spread light layer of fine screenings of broken stone over the surface and brush in dry. Water and repeat brushing until the surface is filled. Alternately water, brush and roll, applying additional screenings if necessary, until all of the voids are filled and a solid, even surface is obtained. The surface should be saturated during the final rolling. After this final rolling, brush a light layer of broken-stone screenings over the surface. The finished road should be crowned about ¼ to ½ inch to the foot and should have appreciable shoulder. *Comments:* The success of this type of roadway depends largely upon the thoroughness of the rolling, and only a heavy roller should be used. This is one of the best grades of roadway construction for airports. It will hold up well under heavy usage in any weather, and the life of the surface can be prolonged by bituminous treatments after completion.

Blast Furnace Slag Roads and Runways: There are two classes of blast furnace slag,—the air cooled and water cooled. The latter

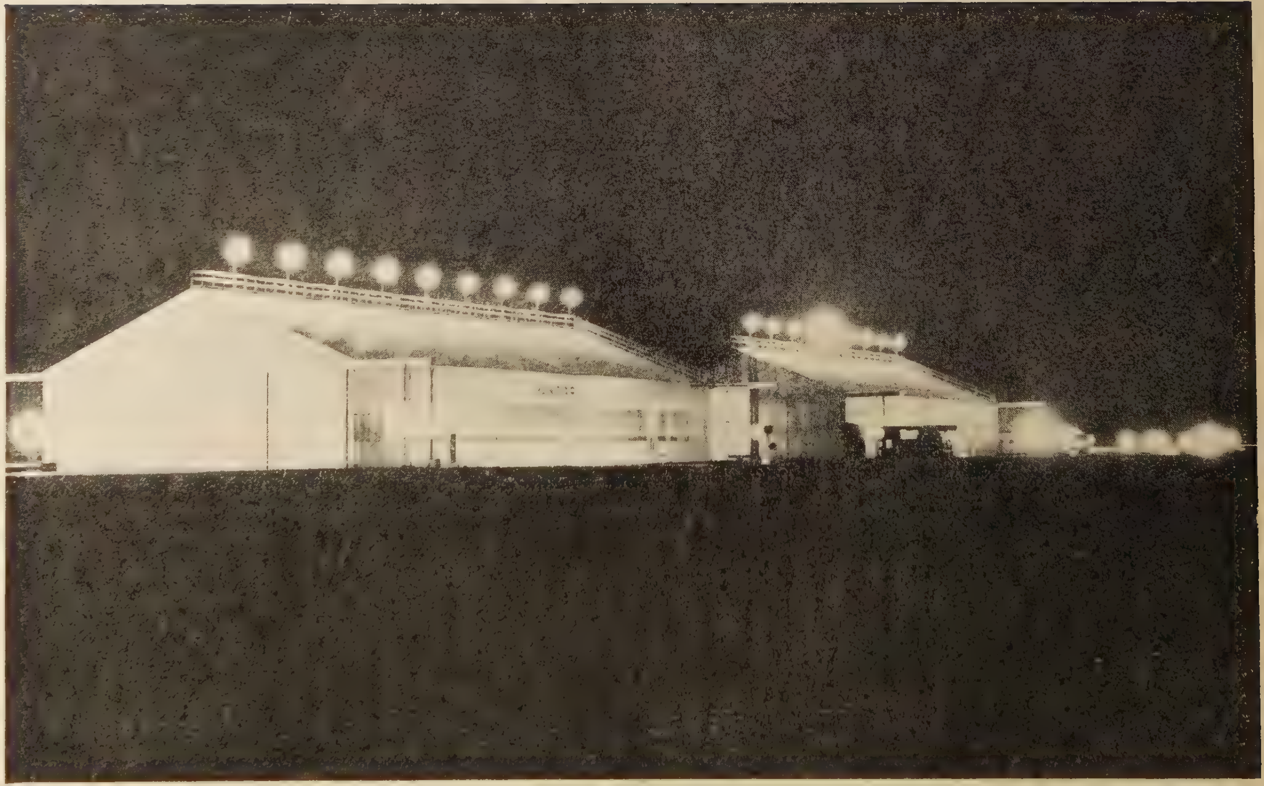


Fig. 26.—Night view of Boeing hangar at Oakland, Calif.

is seldom available and is but infrequently used in road work. Air cooled slag may be used in place of broken stone and, if of good quality, will give excellent results. Care must be taken to secure slag which is free from pieces of iron and sharp particles. In the foregoing description of macadam road construction and in the description of broken stone runway construction to be given later, air cooled blast furnace slag may be substituted for the broken stone.

Gravel Runway—Construction: After completion of the sub-drainage, where such is used, level off the runway area and roll the soil, crowning it about 1/4 inch to the foot of width. Spread over the full width coarse gravel to a depth of about 4 inches. Water and roll until solidly compacted. Spread about 1½ to 2 inches of medium size gravel over the first and roll. The finished surface should be crowned about 1/4 inch to the foot, should be reasonably firm even if not as solidly compacted as a roadway. The sides should taper gradually down to the level of the field, showing no appreciable shoulder. *Comments:* This makes a fairly satisfactory type of runway and is very economical where gravel is available at the site.

Cinder Runway—Construction: Prepare the soil as for gravel runway by levelling and rolling with a crown of about 1/4 inch to the foot. Spread clean cinders over the entire width to a depth of about 8 to 9 inches when loose. Roll at least enough to remove the extreme looseness and to provide a reasonably firm surface. The finished runway should be crowned about 1/4 inch to the foot, should be reasonably firm even if not as solidly compacted as a roadway. The sides should taper gradually down to the level of the field without appreciable shoulder. *Comments:* This makes a very satisfactory type of runway construction for general use, considering cost and service. Blast furnace slag, preferably water cooled, may be substituted for the cinders if more convenient or cheaper. Where either cinders or slag are obtainable at low cost, this construction is economical and should be used. It may be found, particularly after some use, that applications of road oil are necessary to eliminate dust.

Broken Stone Runway—Construction: Prepare soil as for gravel or cinder runways by levelling and rolling to a crown of about ¼ inch to the foot. Spread large broken stone, about 2- to 3-inch sizes, evenly over the entire surface and roll wet until a depth of about 4 inches of solidly compacted stone is obtained. Spread medium broken stone, about 1-inch size, over this surface to a depth of about 2 inches, water and roll until firm. The finished runway should be crowned about ¼ inch to the foot, should be firm, and the sides should taper gradually down to the level of the field without appreciable shoulder. *Comments:* This is a very satisfactory type of runway and should be used where the slag or cinder construction is too expensive.

Surface Treatment: The surfaces of gravel and macadam roads, and to some extent also the surface of cinder and sand roads and the surfaces of runways, can be improved and protected by treatment with bituminous binders. The material marketed under the trade name of Tarvia-B is both an excellent and convenient composition to use. Where roads or runways are to be treated, all dirt or screenings, whether loose or caked, should first be removed from the surface to be treated. At a time when the surface is perfectly dry, about 1/3 to 1/2 gallon of the liquid should be evenly distributed over each square yard of surface in either one or two applications. The road or runway should be allowed to stand unused for about 24 hours for it to become absorbed. At the end of this time, stone, slag, or gravel, about ½-inch size, should be distributed over the surface, allowing about 1 cubic yard to each 150 square yards of surface. If more conveniently available, coarse sand may be substituted allowing about 1 cubic yard of sand for each 200 square yards of surface. In cases where it is planned to use this treatment, the crown of the roadways may be decreased to about ¼ inch to the foot, and the crown of runways to slightly less.

CHAPTER VII

BUILDINGS FOR AIRPORTS*

The Buildings Necessary.

Airport buildings will include some of the following in accordance with the character of the airport, the extent of its development, type of traffic and other considerations: (a) Hangars, (b) Repair Shops, (c) Shed for storage of oils, paints, dope and other such materials, (d) Manufacturing buildings, (e) Garages, (f) Administration, control-tower and office; (g) Restaurant, (h) Passenger waiting room and comfort station, (i) Club house for flying club, (j) Pilots' building with lockers and showers, (k) Hotel or other sleeping accommodations, (l) Radio building, (m) Post office (n) Freight warehouse. This is a very complete list, including every type of building likely to be required at the most complete airport in the future. Many airports of today require only a few of the buildings listed. In most cases it has been the custom to provide several rooms in one central building so that various needs can be met without the expense of a group of separate buildings. In developing the plans, all of the probable needs should be considered and the building arrangements adapted to meet such needs as are liable to arise at that particular airport.

Requirements of Hangars.

Hangars are usually the buildings deserving of first consideration and before any decision is made on the type to be used, several points must be carefully considered. Information should be obtained on the dimensions of the airplanes likely to be housed and this should be studied before any other step is taken. Construction of

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* Prepared with the cooperation of John C. Worthington, Engineer; Black & Bigelow, Inc.

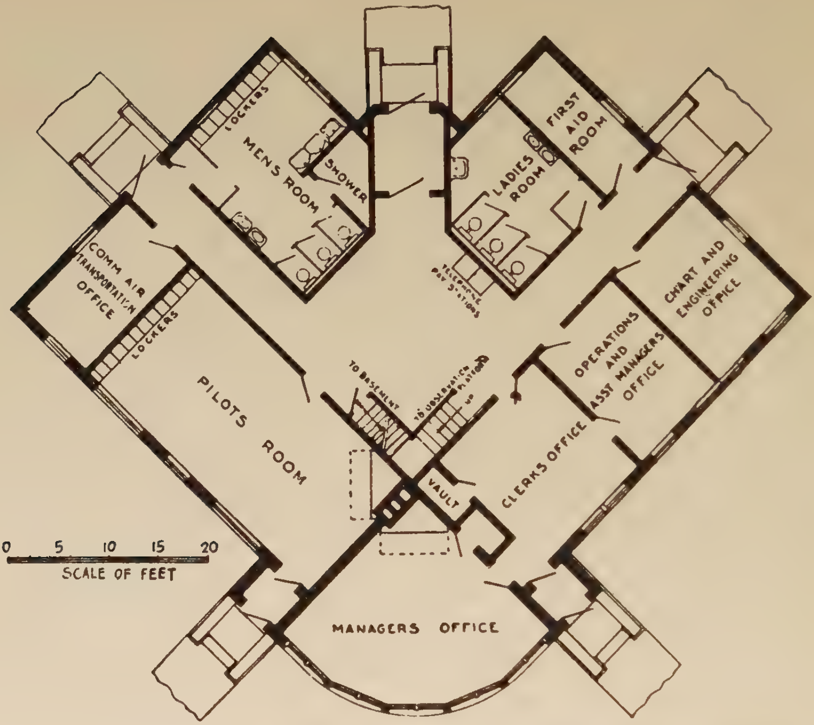


Fig. 27.—Plan of Administration building at Buffalo Airport. (Development of the Buffalo Airport, J. M. Satterfield, Mechanical Engineering, 1928).

hangars without first assembling such information may occasionally result in either waste of space or in the provision of hangars in which some of the visiting airplanes in the near future cannot be housed. Appendix 1 gives the housing dimensions of a wide range of airplanes including both the water and land types built for transport, miscellaneous commercial, instruction, and private use. This list may be regarded as fairly representative of the airplanes likely to require housing at a typical civil airport in the United States. Where in doubt, it is best to err on the side of larger hangars. Local activities must, of course, be considered in using the dimensions from this table in planning the hangars and consideration must also be given to the Department of Commerce Airport Requirements,—for hangar size has a bearing upon ratings allowed. For example, to obtain the highest rating hangars must, among other points, include some with 18 feet clear headroom and not less than 80 feet by 100 feet in size.

Single or Multiple Hangars?

One of the next points to be taken up is the question of whether individual hangars are to be used or whether several airplanes are to be housed in each building. The former method is seldom preferable excepting for very large airplanes as it has the disadvantage of requiring considerably greater investment in buildings. The latter method is more economical in first cost but it increases the possible loss in event of fire. In addition, if the hangar is to be much longer than it is wide and the door is located in one end, it will be impossible to remove airplanes from the rear part without moving those in front. It is this consideration which makes some of the military types of hangars unsuitable for general civil use. Where one hangar would be used jointly by several different owners of airplanes the individual type of building has something to commend it and *might* become the more desirable. As this type gives each lessee a hangar for his exclusive use, it has some advantages, but the increased unit cost of the smaller buildings makes a higher rent necessary. Generally speaking it is safer to construct hangars of sufficient size to house several small airplanes or one fairly large one as this size is more adaptable to changing needs.

Sizes of Hangars.

If only one airplane is to be housed in each hangar, and the maximum size is definitely known, a hangar can be selected which permits the housing of this machine with a minimum clearance all around. Satisfactory clearance between the airplane and walls ranges from about 2 to 5 feet depending upon the size of the machine. Where more than one airplane is to be housed in each hangar, scale layouts of the various airplanes likely to be housed should be cut out of paper and several arrangements tried on the drafting board until the most economical is determined. Ample clearances should be allowed between the airplanes to permit their being moved conveniently. The main door of the hangar should be of such size as to clear the largest machine with at least 2 or 3 feet on each side and the highest part of the machine, with the tail down and the propeller swung out of the way, should clear the top of the door by not less than 12 inches. If practicable, this door should be made sufficiently high to clear the propeller when it is stopped vertically. Unless the project is a large one, it is advisable to consider only the use of standard sizes of hangars as this tends to reduce construction costs. These standard sizes are usually multiples of 20 feet in length, multiples of 10 feet in width and the door heights generally vary from 12 to 20 feet in two-foot steps.

Types of Hangars.

Generally speaking, hangar construction can be divided into five classes. Arranged in the order of their usual cost these are: (1) tent; (2) canvas on rigid frame, usually of wood; (3) all wood; (4) all steel and (5) the factory type of brick or other walls, steel sash, and timber or other roofing. The tent hangar is merely a temporary housing, being a canvas tent shaped to house the airplane, and it should never be considered for any other purpose than emergency use. Indeed, its value even as a temporary hangar is to be questioned. The second type, canvas on wood frame, is almost equally temporary and only a poor makeshift at best. Contrary to a fairly common impression, it is not practicable to erect this type and to later replace the canvas with wood siding. The frame is designed only to carry the canvas covering and is much too light to support the greater weight of wood sides and roof. The all-wood hangar can be regarded as a permanent type of construction and has been used to quite some extent in this country. It was in fact the first to be used. This type is, however, rapidly being supplanted in public favor by the all-steel and factory types which

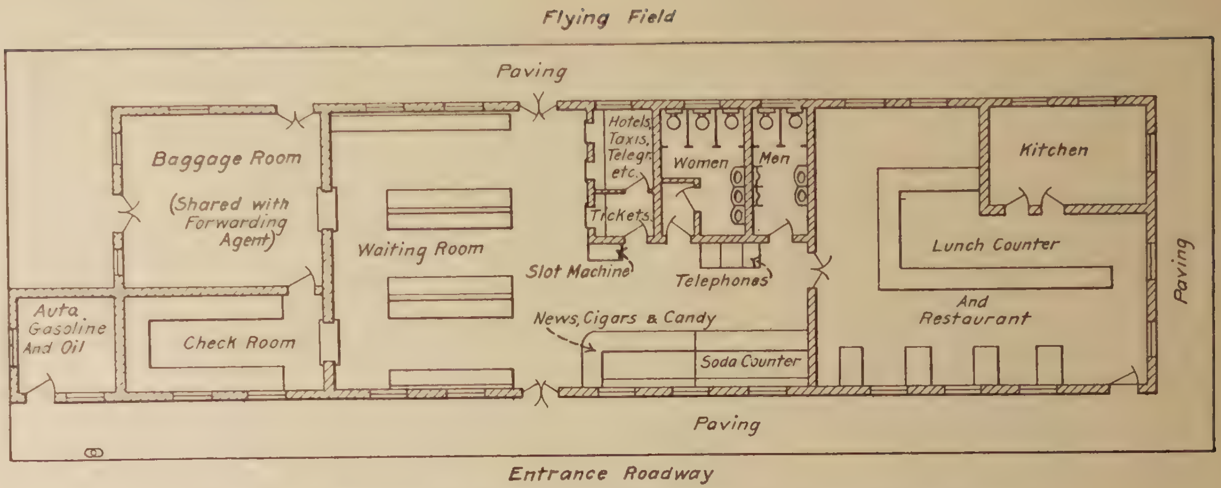


Fig. 28.—Arrangement of passenger building for air transport operations.

have the advantages of longer life, better appearance and lower fire risk.

All-Steel and Other Types.

The standardization of the steel hangar has brought its cost down to the point where it is comparable with wood and sometimes cheaper, hence it is a very desirable type to consider. The factory type of building is a more expensive kind of hangar from the viewpoint of first cost but it is also the highest grade, is the most permanent, and has the lowest maintenance cost. It also has the advantage of removing the temporary appearance given to an airport studded with galvanized buildings. For these reasons among others, it becomes particularly suited to cases where the airport is permanent or where airplane maintenance work is to be carried on. In certain climates airport construction costs can sometimes be reduced by providing outdoor storage for airplanes. Indeed, seaplanes are often moored on the surface of the water because of the inconvenience of hauling them out every day. However, this method must be used with caution as it somewhat increases the airplane depreciation. It also has the disadvantage of not providing adequate protection to mechanics while at work. Another method reducing the building investment, but which again is not always practicable, is to construct the hangars shaped to fit the airplane instead of being rectangular. This gives a building of T-shape in plan and, while costing more per square foot of floor space, the cost per airplane is sometimes reduced. This type of building is often suitable for private owners, but never for public or commercial airports, as its use is limited to practically one type of airplane.

Types of Hangar Floors.

Five types of floors have been in general use in hangars up to date. These are: (1) sand or gravel; (2) cinder; (3) wood, and (4) concrete. The first is entirely unsuitable, being really no floor at all. The second is but little better, although if properly laid and rolled, it may be satisfactory for hangars which are used only for storage. The last two types of floor are each most satisfactory so far as performance is concerned, and are considerably more suitable for hangar or shop purposes than the cheaper floors. Hence they should be considered in every case where funds permit. The sand and gravel floor is constructed merely by filling in the area within the hangar with sand or gravel to a few inches above grade and rolling until firm. The gravel may be screened into two sizes, the larger spread first and the smaller last to provide a smoother finish.

Hangar Floor Construction.

The cinder floor is constructed by spreading clean cinders and rolling until firm. The finished floor should be about 6 inches thick, which will require spreading of the loose cinders to a depth of about 9 inches before rolling. Usually this 6 inches raises the finished floor above the surrounding soil sufficiently to ensure dryness but it may be necessary to raise it further if the soil holds much water. When necessary, additional height may be obtained by filling in with subsoil and thoroughly rolling before spreading the cinders. The cinder floor absorbs gasoline and oil and also provides a firm footing but it hardens with continued use and may retain pools of water or become slippery with oil. When this condition develops, it may be necessary to restore the surface to its original state by spreading and rolling a couple of inches of additional cinders.

Wood and Concrete Hangar Floors.

The wood floor may be constructed by first laying a cinder base as described. On this base are set 3-inch by 4-inch creosoted sleepers laid flat and about 18 inches between centers. Rough yellow pine subflooring, 1-inch thick and creosoted on the under side, is then laid and fastened to the sleepers. The finished floor, which may be 1-inch yellow pine or maple, is laid diagonally over the subflooring and well nailed to it. When the highest grade of wood floor is required, it should be laid over concrete. Where concrete floors are required, they should be constructed by first levelling and thoroughly rolling the ground. Rough concrete of about 1 : 2½ : 5 mix should then be spread evenly to a depth of at least 5 inches and preferably 6 inches after tamping. The surface should then be finished with a straightedge or a wood float. An alternate method is to lay a 4-inch or 5-inch base and, when this has set, to apply a 1-inch finish coat of 1 : 2 mix concrete, the surface being finished with a straightedge or wood float as the conditions may require. The use of a steel float is not advisable as it leaves a surface which is undesirably smooth. Concrete hardeners applied to the floor surface will greatly improve its wearing qualities and decrease dust.

Hangar Doors.

Perhaps the most important single feature of the hangar construction is the door through which the airplanes are moved. Several types of hangar doors which have been in general use are shown in Figure 29. The horizontally hinged type have been found to operate well when new, but they do not stand up under rough and constant usage. As airport equipment is exposed to high winds, and sometimes even neglected, these types should be regarded as unsuitable through their liability to damage. The curtain type of door is by far the most economical so far as initial cost is concerned but it requires considerable care and must be securely tied at all times. For temporary use it stands up fairly well, but it is not suitable for permanent installations. Where a cheap, temporary door must be installed on account of limited funds, this type may be used excepting where exposed to extremely high winds; in such cases one of the other types will have to be substituted. If curtain doors are installed, a rigid rule must be made of always fastening the curtain whether open or closed.

Higher Grade Doors.

The side sliding and the rolling shutter types of doors are each satisfactory but fairly expensive. However, they require less maintenance than the curtain door, are probably cheaper and certainly less troublesome in the end. For all ordinary purposes these doors can be generally recommended. The motor-operated types, whether

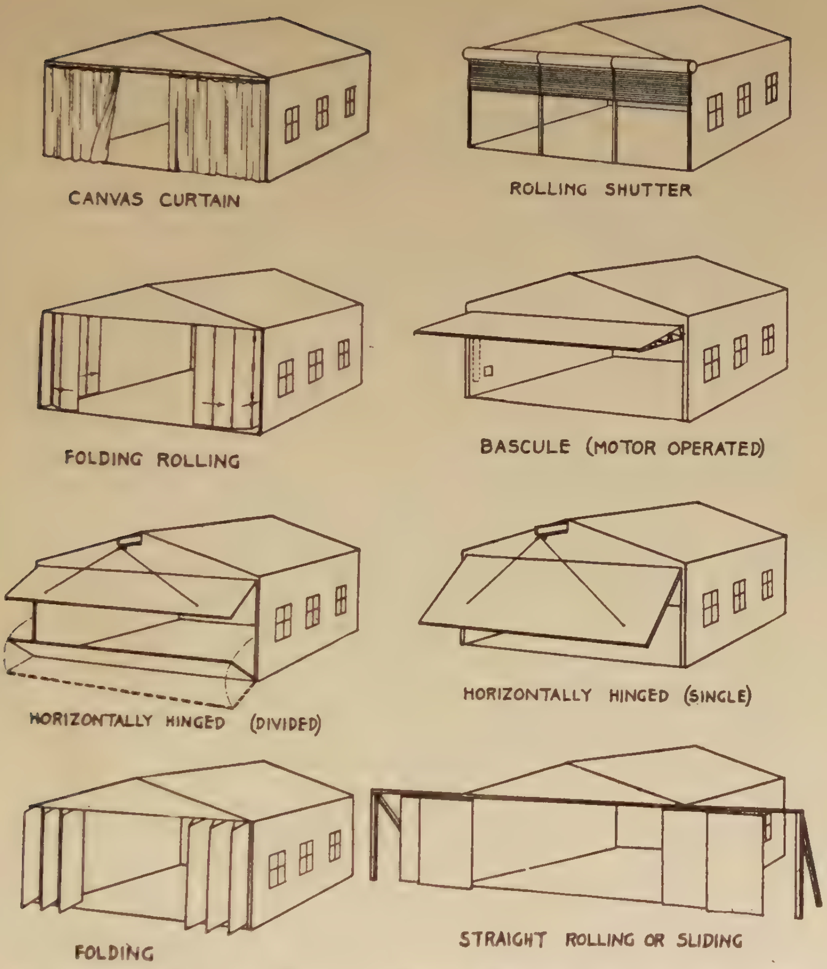

CANVAS CURTAIN
ROLLING SHUTTER
FOLDING ROLLING
BASCULE (MOTOR OPERATED)
HORIZONTALLY HINGED (DIVIDED)
HORIZONTALLY HINGED (SINGLE)
FOLDING
STRAIGHT ROLLING OR SLIDING

Fig. 29.—Types of hangar doors which have been used in the United States. The rolling steel shutter and bascule types are usually operated by power.

bascule or rolling shutter, are the best types available and consequently are the most expensive also. The hand-operated rolling shutter is also an excellent type of door but it is not so convenient to use as the motor-operated type. Indeed, the utility of very large *hand-operated* rolling shutter doors is open to some question on account of the number of men and length of time required to open them. The limits in practical width of steel rolling shutters necessitates using several widths of individual sections to close the ordinary hangar opening. This, at the same time, requires the use of folding guides which must be moved out of the way after the shutters are raised. Whether the additional cost of these higher grade doors becomes justified will depend upon the needs of the particular project.

Shops and Garages.

No general rule can be laid down for the area of shop and garage space required at an airport for any given number of airplanes. In the case of many public airports, the question of shop space can be taken care of by using space in the hangars themselves. For this class there will often be sufficient area around the airplanes to provide room for work benches and space for the repair work. In the case of organized air transport or other commercial flying, and at many large public airports, the repair work may be concentrated in one building for reasons of efficiency. As a general rule for most airport projects a thoroughly practical method of arranging for shop space is to provide each hangar with a small lean-to, heating it where necessary by means of a small stove. In many cases two or three hangars of substantial size and each equipped with a heated lean-to will be sufficient to start with for both airplane storage and repair. For the airports of organized air transport or other commercial operators each case must be planned to suit the particular conditions of the operation. Garage space requirements are subject to similar variation. In this case frequently the best policy is to set aside a convenient plot for the future garage and to erect no building until actually required. When the need arises, a suitable garage can be erected leaving space for expansion at the side and in the rear. As expansion becomes necessary, additional sections can be added to the original building. If a standard-

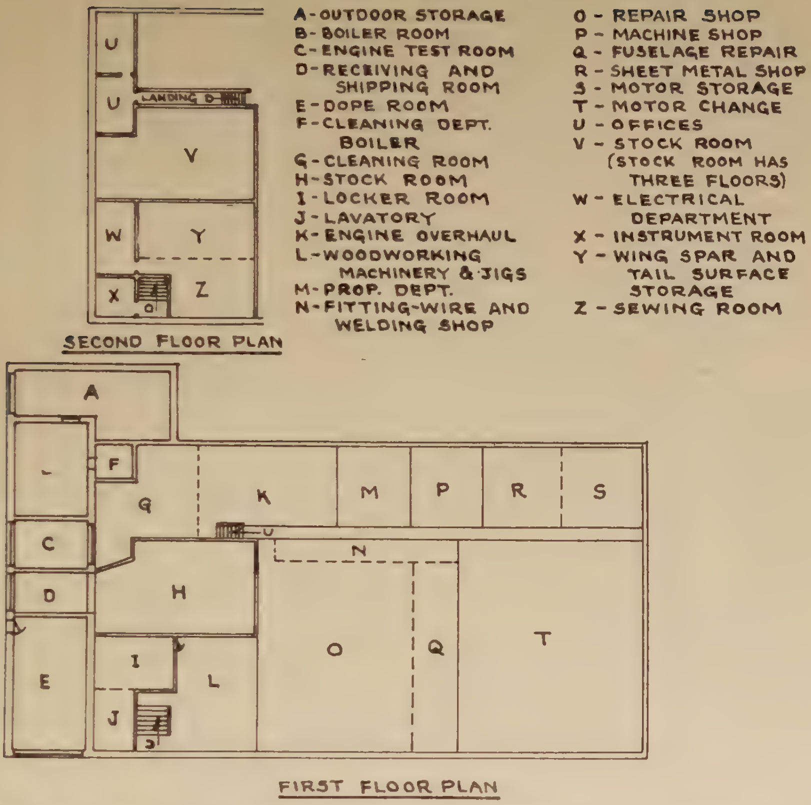


Fig. 30.—Chicago maintenance base shop of National Air Transport Inc. (Reproduced by courtesy of L. D. Seymour, Gen. Mgr.)

ized steel building is used the former side or rear end covering may be removed to the new side or end wall of the structure.

Flooring, Light and Heat.

Wood flooring (either block or plank) is much to be preferred for shop and office buildings and is the only really satisfactory floor for this purpose. The planked wood floor can be considered as best for general airplane shop and office purposes and the wood block as the most practical for machine shops, engine overhaul shops and similar buildings. For garage purposes, concrete flooring is the most suitable. The use of any type of wood flooring for either hangar or garage purposes is not advisable. All buildings, and particularly shops and offices should be well lighted, both by daylight and artificially. Buildings, or parts of buildings, used for shop purposes and offices should be heated when necessary in cold climates, otherwise the working efficiency of the force may be impaired. It is not usually considered necessary to heat airplane hangars but this is sometimes done by means of hot air heaters. In cases where they are not heated, a lean-to should be built and this building should be heated so that work on maintenance may be carried on without discomfort.

Miscellaneous Considerations.

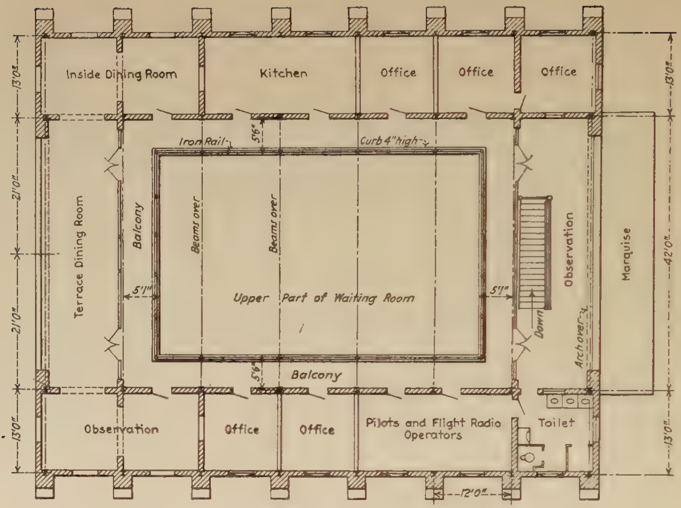
In selecting types of buildings for hangar and shop use, consideration should be given to the necessity of occasionally lifting engines out of the airplanes and at least some of the roof trusses should have sufficient strength to permit their being used for suspension of chain tackle. So far as the type of construction is concerned, shop buildings may be similar to the hangars. Standardized steel buildings are particularly suited for garage use, but it must always be remembered that it is not economical to heat steel buildings which are not lined on the inside. Dope rooms in airplane shops should be separated from the rest of the shop and should be ventilated directly to the outer air. If much doping is to be done, this ventilation must be obtained by use of an exhaust fan. Whenever practicable each hangar and shop building should be equipped with at least one wash sink, hand basin and water closet. The larger shops will require several of these.

Office and Waiting Room Space.

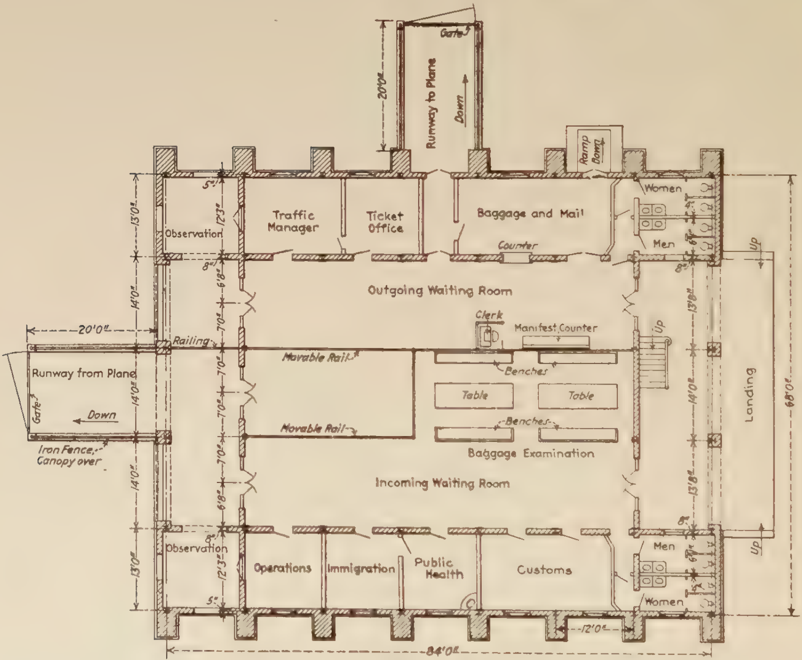
No matter how small the airport equipment may be, some suitable heated and lighted space should be provided for office, waiting room, stockroom, and other purposes. The larger airports will require a substantial administration building. In cases of very limited activity a lean-to against the hangar or a building of 20 feet by 20 feet may be ample for all of these purposes. If some type of standardized sectional wood building is used where very little space is required it can be extended or moved from time to time as the airport equipment expands. Buildings of this type are available on the market at nominal cost and can often be erected for less than the cost of a permanent wood building erected by a local contractor. The sectional type of building is actually constructed complete in the factory disassembled into sections about 3 by 8 feet and reassembled in the field by unskilled labor by merely bolting all of the sections together. Heating of small buildings used for office, waiting room and similar purposes is usually most conveniently arranged by installing small, round stoves. At an airport where no repair and construction is done, heating of other buildings may be dispensed with. The partitions obtained with standard sectional buildings can be used to divide these into rooms for office, lockers, waiting room and toilet. The addition of a toilet with hand basin and water closet is very necessary and in every case where running water is available this should be included.

Administration Building.

When an important airport is being planned it is very advisable to include provision of an administration building. This structure can be designed to house the offices, passenger waiting room, ticket office, pilots' lockers, toilets, mail and freight storage, and lunch room or restaurant if desired. Indeed, an excellent plan is to design a suitable and permanent building to house all of these under one roof. When traffic develops to the point where additional space is required the original building may be extended from time to time or certain of the activities (such as the waiting room, ticket office and restaurant) may be moved to new buildings located nearby. The particular plan to be used for any airport administration building must be designed to meet the requirements of the location,



SECOND FLOOR PLAN



FIRST FLOOR PLAN

Fig. 31.—Floor plans of Pan-American Airways terminal building, designed for erection at Miami, Fla.

but some of the accompanying illustrations show plans and photographs of several typical buildings.

The Traffic Control Room.

It is desirable to incorporate in the design of the administration building a "control room" for use in directing flying activities. Such a room can best be arranged by placing it as a tower on the roof of the building above all obstructions to vision and providing a continuous row of windows all around the walls and in the roof to permit a clear view of the field and all of the surrounding air. This control tower will become necessary in directing take-offs and landings when expansion of flying activities brings continuous traffic to the airport. It should be provided with telephone connection, fire alarm and emergency call system, direct communication with the radio station and Field Manager's office, landing-light switches, and some means (such as lights or siren) for signalling to incoming aircraft. The room should be completely encircled by an open-air balcony for use of the Traffic Controller in good weather. While the control tower should be adjacent to, and directly connected with, the Field Manager's office, the two offices should never be combined permanently in one room.

CHAPTER VIII

AIRPORT MAINTENANCE AND OPERATING EQUIPMENT*

Major Divisions of Equipment.

Leaving aside the questions of buildings and of repair facilities, which are taken up elsewhere in this volume, equipment of airports may be classified into three divisions: (1) Maintenance and general; (2) Servicing; (3) Operating. In Appendices 2, 3 and 4, items in each of these classes have been listed in an all-inclusive manner not indicative of the needs of any particular case. Indeed, equipment is so greatly influenced by conditions that some airports need only a few essentials while others require elaborate facilities. The relative importance of individual items is similarly affected and on this account no effort has been made to arrange the listing in some definite order. At the same time those who have occasion to buy equipment for airports should find the tables useful guides when compiling lists of their requirements. A wind cone, gasoline and oil storage, water supply and a telephone connection constitute perhaps the first essentials of flying field equipment. Others become necessary and must be added in accordance with the type and importance of the project.

Maintenance and General Equipment and Facilities.

Electric light and power is very desirable and in cases where the supply cannot be obtained from outside sources, a farm lighting unit should be installed. In determining the capacity of this set not only must the area of the buildings be considered for lighting, but the possible use of water and oil heaters, electric tools and night flying equipment must also be allowed for. The last mentioned requires a considerable supply of power if large units are used. Field maintenance equipment is very often omitted yet a small tractor with grass cutting, road drag and snow plow attachments, or a snow roller, will be found valuable additions to any airport. With these the surface of the field, roadways and runways can be maintained by the airport staff with moderate labor and at small cost. In cases where very heavy snow is to be expected during the winter months it may be necessary to furnish some equipment for rolling it down on the field (to provide a firm surface) instead of attempting to clear it away to one side of the runways. A suitable roller for this purpose can be made of some discarded cable reels and 2-inch planking, if not available ready-made. In practice it has been found that about 5 feet in diameter and about 12 to 15 feet long make satisfactory proportions. This roller can be furnished with an axle and drawgear made of iron pipe and may be pulled either by horses or by a farm tractor. In using it the entire area of the field in general use should be rolled until the snow is hard enough to provide a firm surface. Complete fire protection equipment must also be included in the list to be furnished, but as this question is to be

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* Prepared with the cooperation of J. E. Whitbeck, Pan-American Airways, Inc.

Fig. 32.—"Gassing-Up" an airplane at the aero garage operated by the De Havilland Aircraft Company on its field at Edgware, a suburb of London, England. The lady standing on the fuselage and bending over the wing is Mrs. S. C. Elliott Lynn, the owner and pilot of the 'plane.

taken up in detail in a later Chapter, it will not be covered here. Some means of transportation for personnel and materials is also necessary. If a light motor truck is furnished, this can be used for carrying materials and also for transporting the staff to and from the airport, for answering emergency calls and even for some field maintenance work. It may also be of help in hauling out small seaplanes under favorable conditions, but the tractor is preferable for this use.

Gasoline Storage Tanks.

The safest, most economical and most generally satisfactory method of storing gasoline is in underground tanks which are equipped with pumps. Where any reasonable quantity of gasoline is consumed, the oil companies are generally ready to install and maintain the tanks at their expense. A nominal rental is charged and the airport operator is required to use the tank installation exclusively for the products of the company making the agreement. So long as the deal is made with one of the established firms this restriction works no hardship and frequently means no change in buying policy. The tanks should never be located under any buildings, roads or runways and the filler pipe and vent should always be some distance, say 50 to 100 feet, from every building other than a gasoline and oil house. The pump should be of the locking type or should be enclosed in a gasoline and oil house to prevent pilfering. Where the installation is made under arrangement with some oil company, it is customary to provide a measuring pump capable of being locked. In all cases where these pumps are to be used for filling airplane tanks directly, they should be equipped with an extra long hose, at least 15 and preferably 25 feet. This hose should be attached to the top of a vertical riser pipe about 15 feet high to facilitate use.

Barrel Racks and Handling Facilities.

While the underground tank installation is the most advisable for both gasoline and oil it may be necessary to handle these in barrels, in which case a rack will greatly facilitate the work. Such racks may be constructed of lumber and should provide for at least one full and one partly full barrel of each kind of oil. Excepting where a track and chain tackle are installed over the rack or where skids are provided, the racks should be made sufficiently low to facilitate the work of changing barrels. For this reason, a rack about 18 inches high will usually be found most convenient. When oil or gasoline are used inside of hangars or shops it is desirable to keep these in either portable safety cans or portable tanks of the type used in garages. It is sometimes necessary to provide a means of quickly filling the gasoline tanks of large airplanes. This can be arranged by means of an elevated gasoline drum which is filled at leisure by means of the measuring pump and is equipped with a large diameter hose, about 2 inches, to permit its being rapidly emptied into the airplane tank. Equipment of this type has been installed in some hangars by suspending the drum from one of the trusses near the main door. However, it is most desirable to keep such quantities of gasoline outside of the hangars and preferable systems are those of placing the drum on the roof of a separate gasoline and oil house or the system referred to in the next paragraph. In providing for gasoline and oil storage equipment at airports, it is usually necessary to provide for storage of about 15 to 25 times as much gasoline as oil, but this ratio may be affected by purchasing considerations.

Special Gasoline Distributing Systems.

A very practical gasoline distributing system has been developed by S. F. Bowser & Company and installations have been made at some modern airports. This system makes use of underground storage tanks, a piping system with several outlets at convenient places around the active side of the airport, and an electrically operated pump to deliver the gasoline. The outlets each consist of a flexible hose mounted on a reel which is arranged in a box, as shown in Figure 33, set into the surface of the field and flush with it. Provision for locking of the box cover eliminates danger of

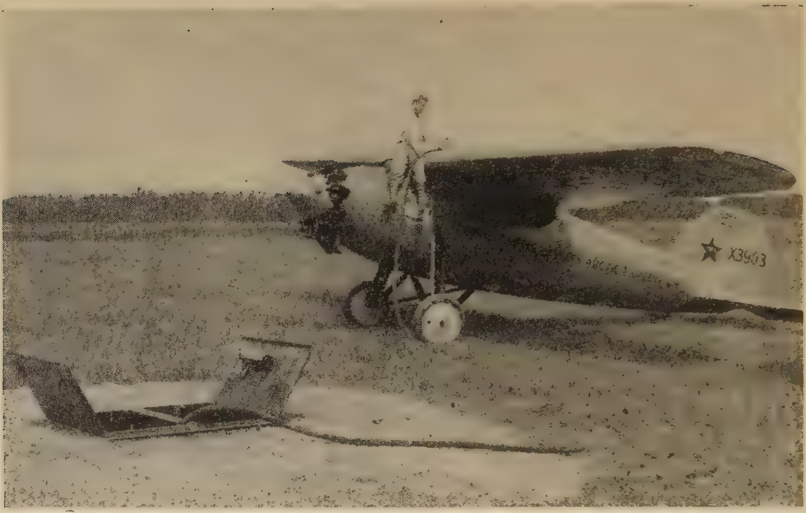

Fig. 33.—A Bowser fueling pit for gasoline service at flying fields.

pilfering of gasoline. These installations usually include a meter in each box for measuring the amount of gasoline delivered to the airplane and they are, therefore, very useful for any type of flying field operations. Often an air line and a water line are included in the installation to provide for servicing of tires and radiators at the same time.

Oil and Water Heaters.

Oil and water heaters are useful additions to the equipment at most airports in northern localities where flying is to continue through the winter. Not only is difficulty experienced in starting airplane engines with cold water and oil in cold weather, but there is also danger of the water freezing in water cooling systems before the engine can be started. In cases where little flying is to be done in cold weather it may be sufficient to arrange a heating system by using a small water-back kitchen stove, or a small boiler, with the connections coupled to circulate the water through an open-top barrel. The water can be drawn from this barrel through a faucet at the bottom while the oil can be heated by placing a can of it inside of the barrel, keeping the top of the oil can above the water level. Where a complete water- and oil-heating system is required it can be arranged economically by use of a small water boiler and two cisterns of the kind used in small buildings. A system of this type can be arranged to provide some building heat and wash water at the same time. In cases where electric power is available it will often be found more convenient to make use of electric heaters. These units consist of heating elements designed for immersing in the water or oil and are made by the Westinghouse Company and others. Electric heating pads may also be used to keep water pipes of engines from becoming too cold.

Wheel Chocks and Handling Dolly.

Among the equipment for handling airplanes on the flying field, wheel chocks and a small truck or "dolly" for carrying the tail skid are most necessary. The chocks are used under the wheels of airplanes to prevent them from moving while the engine is being warmed up and the dolly is used to carry the tail skid of the machine while it is being moved around the field by hand or being taken into or out of the hangar. Wheel chocks can be easily made by the field mechanics from any lumber on hand and they are useful even when the airplanes are equipped with brakes. In other cases they are essential. The dolly can often be improvised from some old wheels, axle and lumber which may be available, but dollies of the lifting type are much to be preferred for large airplanes. The lifting type of dolly is provided with means for lifting the tail of the airplane somewhat after the manner of garage jacks. This eliminates the necessity of lifting the airplane tail manually and in the case of the largest sizes of airplanes it is almost essential. With increased operations at airports it seems likely that a special motor truck or tractor, with tail-lifting apparatus, may be developed to take the place of the simple hand dolly. Such apparatus would be very useful in moving airplanes around the flying field.

Seaplane Ways, Trucks and Wheels.

Where equipment for only water types of airplanes is being considered the wheel chocks and dolly will not be required. Instead, seaplane ways or a track will be necessary and usually some specially designed handling trucks will also be required for the various types of seaplanes. Seaplane ways or tracks should extend from the hangar apron or entrance down the beach to below low water level so that seaplanes may be launched or hauled out without regard to the tide. The types of construction and arrangement of beaching tracks will be discussed in detail in the Chapter on Requirements of Seaplane Bases. Handling trucks for use on these ways or tracks are, of course, provided with flat wheels for the former and with flanged wheels for the latter. In some cases, the handling truck is formed like a cradle to snugly fit the hull, while in others, a separate cradle is used and this is carried on the truck. In still other cases the seaplanes are fitted with sockets to accommodate axles and the wheels are thus attached directly to the hull. With this last arrangement the handling truck is dispensed with and the seaplane taken up the ways on its own wheels.

Mooring and Hauling Equipment.

No special comment seems necessary regarding the mooring buoys required for mooring of seaplanes as the ordinary marine buoy, as used for small power boats, is equally suited for this purpose. Unless the beach is quite flat and the seaplanes are small, some provision must be made to facilitate the work of hauling them out of the water. Crabs, winches, capstans and crawler tractors have each been used for this purpose. The crab or capstan represents the lowest initial cost but requires more labor in use. Hence tractors should be furnished in cases where much hauling out is expected. In others the crab or winch may be satisfactory and suitable types can be bought locally from dealers in builders' equipment or marine supplies. In the Chapter on Seaplane Bases reference will be made to the arrangement of mooring facilities.

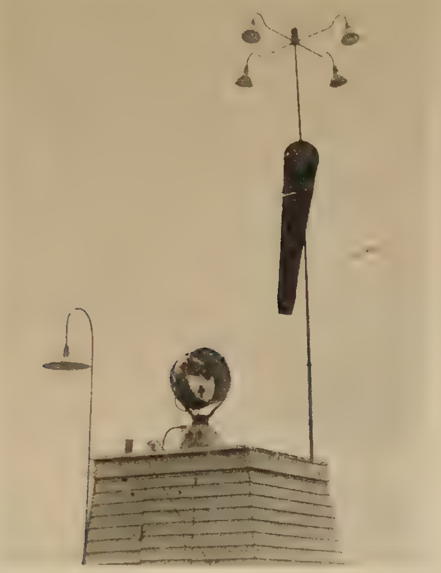

Fig. 34.—Installation of illuminated wind cone and rotating beacon on hangar roof. U. S. Post Office Photo).

Engine Starters.

The portable engine starter is an item which can be omitted until these are further developed. Numerous devices have been made and used here and abroad, most particularly in Europe, but many of these have been experimental and few were marketed. Some portable starters consist of motor trucks carrying a shaft driven by the engine and which can be connected to the airplane propeller hub. Others are operated by compressed air and can be carried around by hand. In the meantime, the use of starters on the airplanes themselves is increasing in popularity and it may develop that there will be little need for portable airplane engine starters at civil airports in the future.

Wind Indicator.

A wind direction indicator is a most essential item of airport equipment. Originally a pennant was used for this purpose but it has long since been displaced by the wind cone, better known in aviation parlance as the "sock." Automatic wind Tees have also been developed, but the wind cone has the advantages of lower cost and of the fact that it gives some indication of wind speed. In military operations the practice was tried of laying out a white cloth Tee on the surface of the field. From time to time the Tee was moved by the station personnel as the wind changed. This method proved to be an abortive one and its use has long since been discontinued. Of the many devices tried out for the purpose of wind indication, the cone has perhaps the greatest advantages. It is economical, automatic, practically infallible, shows every little variation of the wind and even gives the pilot some indication of wind velocity by the angle at which it floats from the mast. Wind cones can either be constructed locally or purchased ready made from some supply house. Experience has shown the best proportions to be: length, about 12 feet; diameter of large end, about 36 inches; diameter of small end, about 12 inches. These dimensions correspond to the Department of Commerce Airport Rating Regulations. The cone itself should be made of a light but strong and flexible fabric such as unbleached muslin and should be colored orange or chrome yellow. The coloring may be obtained by immersing in some oil color

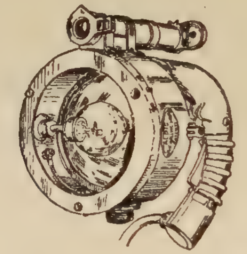

Fig. 35.—The Aldis lamp for signalling to aircraft.

as Pitcairn Chrome Yellow Tector stain, if the cone is not colored when purchased. The small end should have a ring of about ⅛-inch brass wire and the large end a similar but rather heavier ring, each sewn into the hem. The complete cone should be carried by collars mounted on a tubular mast and should be erected in a suitable location where free from local gusts created by buildings. Frequently a position well above the roof of a hangar will be found most suitable. Where there is even a remote possibility of night flying the wind cone should be lighted in accordance with the method described in the Chapter on lighting.

Miscellaneous Equipment.

First aid kits should always be furnished and are called for in the Department of Commerce Rating Regulations. The type and number of these must take into consideration the number of men and scale of operations at the airport, but the Department of Commerce minimum requirements call for: 12 assorted bandages, 12 sterile dressings, 2 tourniquets, a supply of first aid dressing for burns, adhesive tape, a supply of either tincture of iodine or mercurochrome, aromatic spirits of ammonia, and a paper or glass cup. Ambulance facilities are necessary at large airports. Some meteorological apparatus is desirable if the airport is to be an active one and the more essential items, such as wind speed indicator, thermometer, barometer and rain gauge can be obtained at low cost. Where activities attain some importance, these instruments should be of the recording type and in charge of some responsible person. A megaphone is a most useful addition to the equipment and can be used for many purposes such as issuing orders to mechanics some distance away, ordering unauthorized persons off the landing areas, and calling of individuals to the telephone. The ordinary large-size hand megaphone is usually sufficient.

Traffic Control and Lighting.

In cases of airports which are centers of traffic it becomes necessary to make special provision for traffic control. This provision might take the form of an elevated platform or a tower atop the administration building and carrying a small office for use in directing operations, as described in the Chapter on Buildings. Where such equipment is provided, the landing lights should be capable of operation from the control tower and the tower should be furnished with telephone, fire alarm and radio station connections, with a loud speaker and megaphone and some facilities for signalling to aircraft

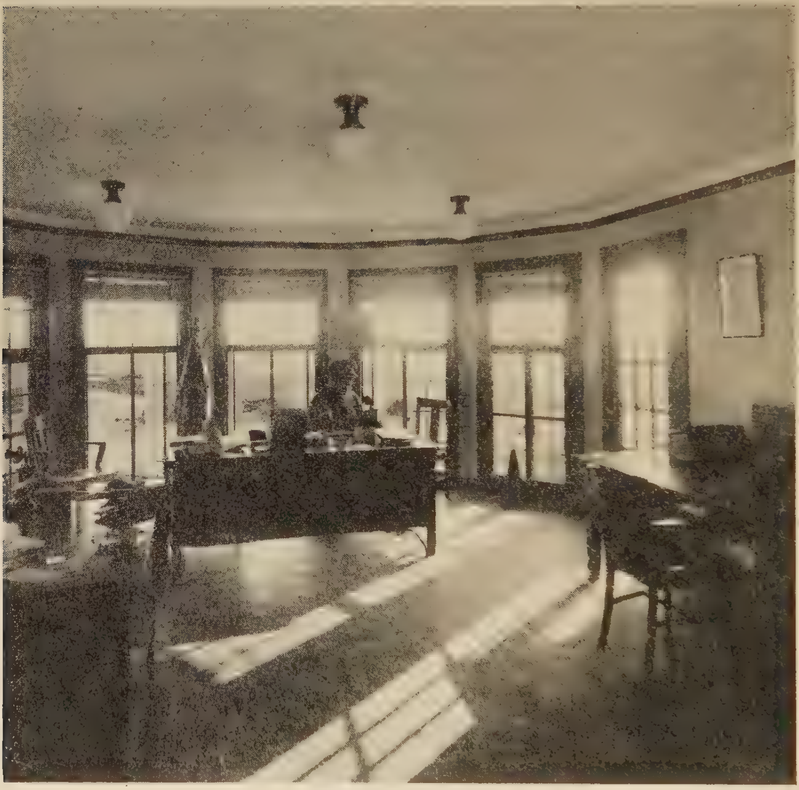

Fig. 36.—The Superintendent's office at Oakland, Calif., Municipal Airport. This photograph was taken before completion of field construction, hence the torn-up area which can be seen through the windows.

in the air. At Oakland, California, Municipal Airport, a powerful siren is used for the latter purpose. The Aldis signalling light shown in Figure 35 is an English development which has been used for this purpose abroad. The Aldis device consists of a high-power electric bulb mounted in a projector which is provided with a handle and a telescopic sight for directing the rays. In use the light is held in the hand and pointed toward the airplane by aid of the sight. It is flashed by means of a trigger and grip switch to provide the signal and is sufficiently powerful for day as well as night use. Some thought is given also to other methods of signalling to aircraft and the near future should see important advances in this direction. The question of night flying lighting must also be taken up in equipping the airport, but this subject will be covered in a separate Chapter.

CHAPTER IX

REPAIR SHOP EQUIPMENT FOR AIRPORTS*

General Classes of Equipment.

Equipment necessary for repair of land planes, seaplanes and their engines may be divided into the two general classes of "airplane repair" and "engine repair." As with maintenance and operating facilities, the necessary repair equipment will vary with the use of the airport. Consequently, it is impossible to have here a list of equipment which could be regarded as typical for any civil airport. Military and Naval stations are well equipped through having more regard for the possibility of rapid expansion than for immediate needs. On the other hand, civil airports, through limited funds, are often provided with less equipment than is really needed. A detailed list of practically all equipment in the above-mentioned two classes is given in Appendices 5 and 6. These tables are very complete and are not intended to represent the equipment necessary at an average airport. The need of each item would, of course, be determined by the type of repair work and its extent, and this might vary with each case. As a matter fact, even some of the most completely equipped airports are not provided with all of the items listed because much repair work is sent to the airplane and engine factories.

Development of Airport Equipment.

The small volume of work and the limited funds available for equipment often confine the immediate purchases of equipment to the barest necessities. Quite often it is only by sending much of the work to the factories that major repairs can be made at all. In the case of airplanes this is not always efficient because of the high cost

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* Prepared with the cooperation of Chas. B. Kirkham, Kirkham Products Co., Garden City, N. Y.

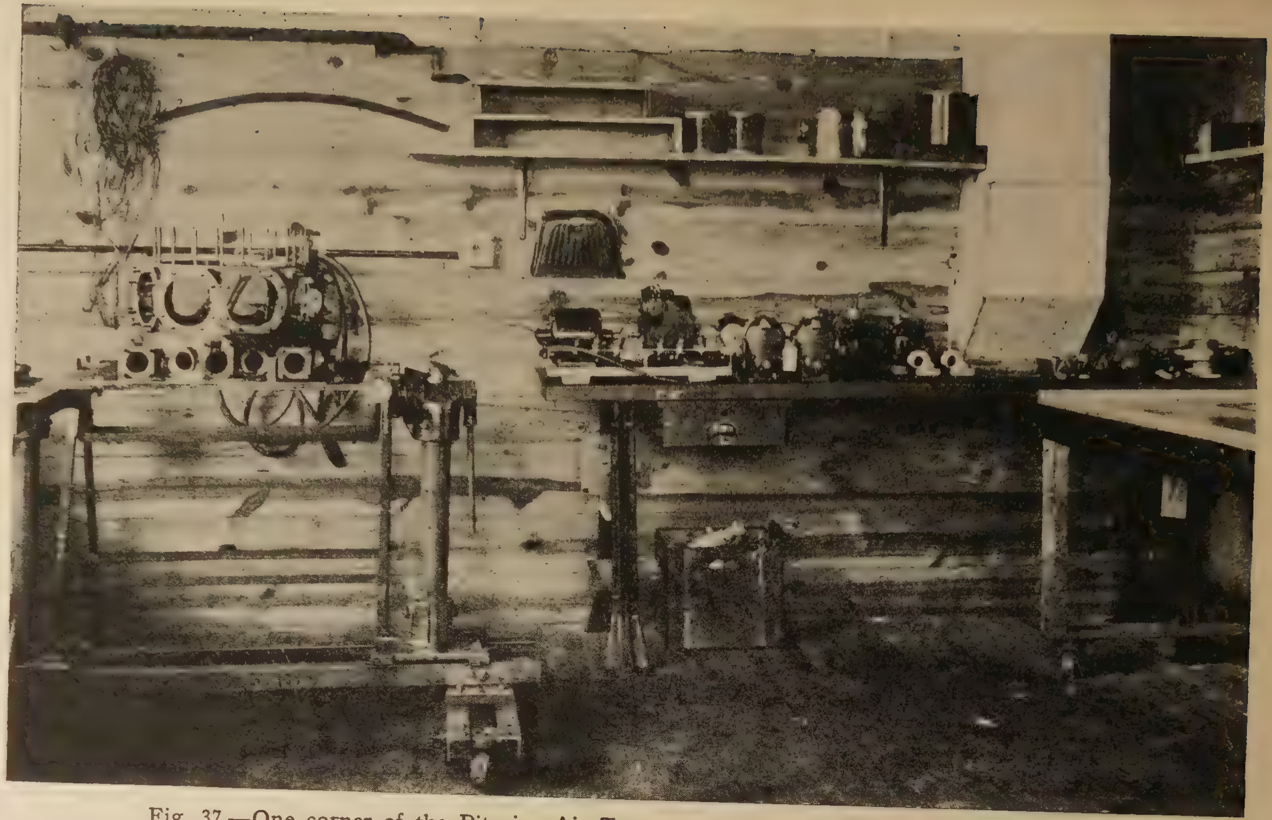


Fig. 37.—One corner of the Pitcairn Air Transport Inc., repair shop at Richmond, Va.

of shipping damaged parts. With engine repairs the case may be different as there are many advantages in sending engine overhaul work back to the factories. The availability there of jigs and gauges for checking parts is a strong argument in favor of sending engine overhauls to the factories in which the engines were built. However, both airplane and engine shops at airports will require increased equipment, with increased operations, until they become comparable with the airplane and engine factories. Even now it is difficult to draw a line between what is strictly factory equipment and what may be considered as both airport shop and factory equipment. Hence the list given in Appendix 5 overlaps somewhat into the factory class of equipment and as given it would provide sufficiently for entire construction of airplanes. As this may become future practice at *some* airports, the table has a proper place in this volume.

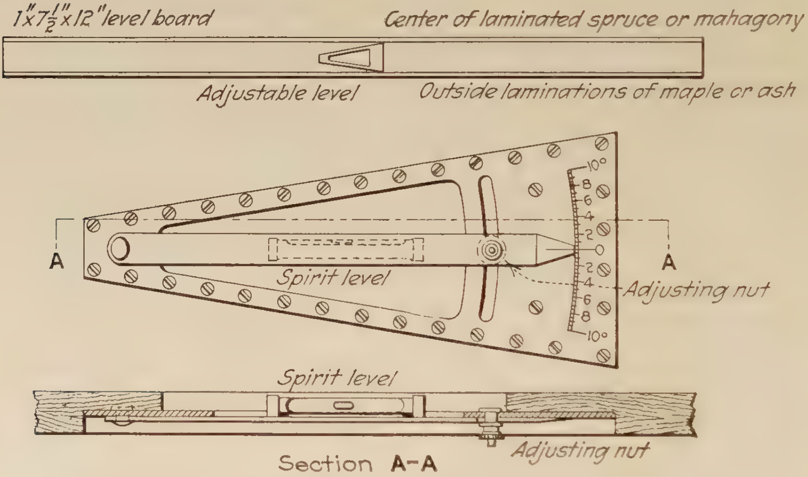


Fig. 38.—Special type of level for use in checking dihedral and incidence angles when rigging airplane wings. Required chiefly for work on wire truss biplanes.

Airplane Repair Needs.

Where no extensive repairs of airplanes are to be made, only one or two benches and a few hand tools will be necessary. These benches should be somewhat like the type used by carpenters and should each be furnished with a carpenter's vise and a small machinist's vise. As the volume of repair work grows, its scope will also extend and the list of tools will grow similarly until it approaches that of Appendix 5. Every airport, at which any rigging is to be done on airplane wings with wire trusses, should be furnished with either a 12-foot straight-edge and two-way builder's level or with a specially built level, for the purpose of checking dihedral and incidence angles. Figure 38 shows a special device of this type which has given good service on maintenance work. Woodworking machinery will not become necessary at least until maintenance work is extended to include major repairs on wood-type wings. Even then it will seldom be required if parts are conveniently available from the factories. However, where some experimental work is to be done,

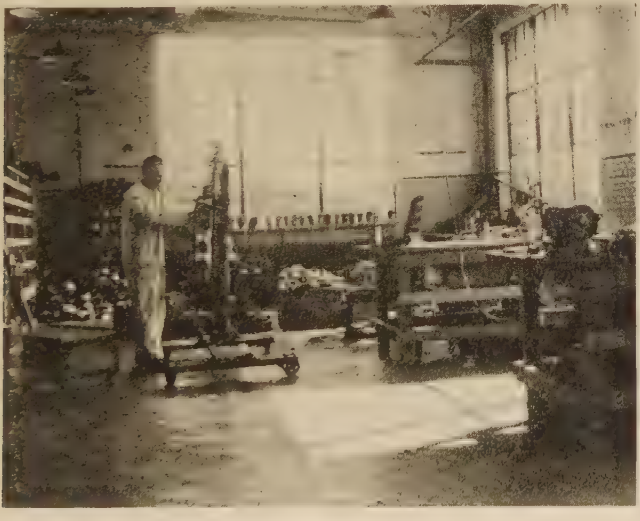


Fig. 39.—Motor repair shop of the New Standard Aircraft Corporation at Paterson, N. J.

which calls for building of wood parts, a band saw, jointer, jig saw and spindle shaper or "variety machine" may be considered the most essential. With such equipment the airport shop could do a considerable amount of wood parts construction.

Propeller Maintenance Equipment.

Where propellers are to be built or where any quantity of them are to be repaired, a checking table, balancing stand and balancing mandrils will be necessary. A satisfactory type of checking table can be constructed as shown in Figure 40, and at moderate cost. This type of table has been thoroughly tried out in several factories in

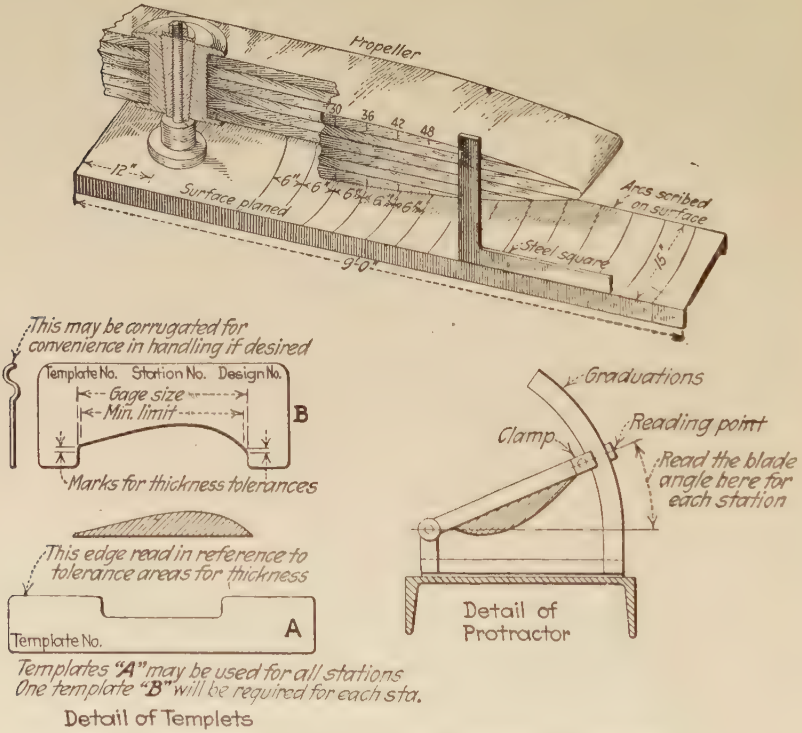
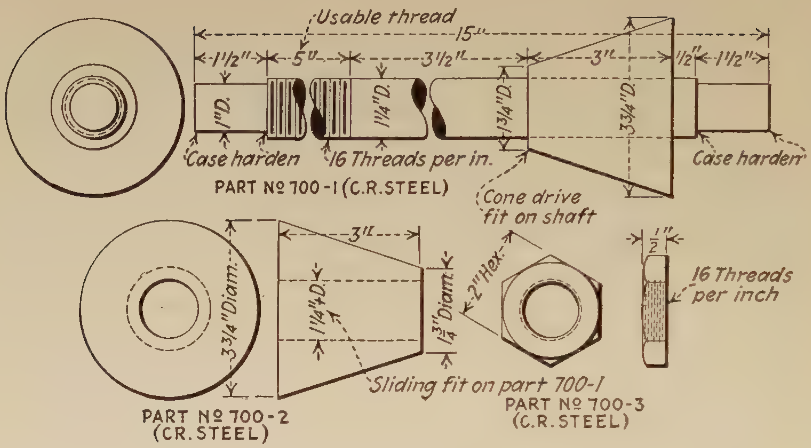

Propeller
30
36
42
48
12"
Surface planed
6"
6"
6¼"
6¼"
6¼"
Arcs scribed on surface
Steel square
9'-0"
15"
This may be corrugated for convenience in handling if desired
Template No. Station No. Design No.
Gage size
Min. limit
B
Marks for thickness tolerances
This edge read in reference to tolerance areas for thickness
Template No.
A
Templates "A" may be used for all stations
One template "B" will be required for each sta.
Detail of Templets
Graduations
Reading point
Clamp
Read the blade angle here for each station
Detail of Protractor

Fig. 40.—Propeller checking table and templets.

past years and costs but little more than a makeshift device. It should be furnished with a checking protractor somewhat of the type shown in the illustration. Two types of propeller balancing stands have been extensively used. In one type the propeller is mounted on a mandril and laid on two parallel level tracks so that it is free to roll. If out of balance, it will roll until the heavy side is down. In the second type, the propeller is mounted on a mandrill which rests upon two pairs of rollers, permitting it to turn freely. This latter type is the most satisfactory. To avoid the necessity of keeping on hand several different sizes of mandrils to fit all propellers, a universal propeller-balancing mandril may be made as shown in Figure 41, being modified if necessary to fit the range of sizes used. This type can be used for a wide range of propeller sizes and with any type of balancing stand. Such mandrils can be made by any local machine shop or at the airport if machining facilities are provided.

Wire and Cable Tools.

In most airplanes, wires and cables are used in the control system, and to some extent in the structure. For making up of these wires and cables in quantities, some special equipment is necessary. At any shop where such work is to be done, a hard wire loop bender, cable terminal wrapping device and a cable proof-loading device should be provided. Apparatus of this kind is not available ready-made, hence it will be necessary to construct it specially where needed. The work of wrapping cable terminals can be greatly facilitated by use of a simple and efficient machine such as shown in Figure 42. This tool is designed along the lines of some which gave excellent results in aircraft factories and it can be constructed by use of a commercial breast drill and some other parts. The proof-loading device being of lesser importance, no illustration is included, but one may be constructed of two structural steel channels fastened together with spacers between and with some means, such as a long lever, for applying the load. A weight-lifting mechanism can be arranged to furnish the actual load as required.



Note:- This spindle takes all propellers with bores from 2" to 3 1/2" and hubs up to 10 1/4" thick

Fig. 41.—Universal propeller balancing mandril capable of accommodating a wide range of sizes.

Metal Parts Tools.

Where metal parts are to be made elsewhere and only assembled at the airport, the benches already mentioned will be practically the only equipment needed. As the amount of work of this kind extends, more machinist's benches and other metal shop equipment must be added. Where all-metal types of airplanes are to be repaired, even occasionally, some special riveting fixtures will be needed to suit the particular type of machine. While the tendency toward the air-cooled engine is carrying everything before it, many water-cooled engines are still in use. For radiator repair work a testing bath is necessary if the quality of this work is to be assured. The bath should be one in which the whole radiator can be submerged. A tank of this kind may be built at the airport shop, or by any local tinsmith, of galvanized sheet iron about No. 16 gauge. It should be several inches wider than the radiator and about three inches deeper. In using the tank, the radiator openings are sealed with plugs, it is filled with air at about 6 to 10 pounds pressure per square inch and submerged in the testing tank. Any leaks immediately show up as the air bubbles out. An ordinary automobile tire pump is quite suitable for furnishing the air pressure. For repairing of wheels in any quantity, some type of wheel assembly and truing stand is most valuable. Several makes now sold for garage purposes are equally suited to airplane work. As a general rule it is wise to leave metal parts work to the factories. However, if metal parts are to be made at the airport, and in some quantity, additional equipment will become necessary. Even where the volume of this work is modest, a force press, acetylene welding outfit and a small screw-cutting lathe will each prove a convenient addition to the list.

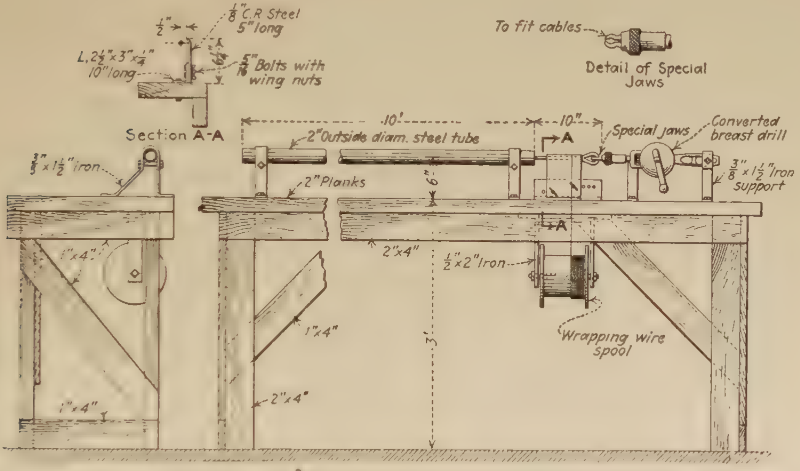


Fig. 42.—Cable wrapping bench for use in airplane shops where cables for wings or controls are made in quantities.

Engine Repair Equipment.

Airplane engine repairs may be subdivided into two classes: minor and major overhaul. The first usually includes such work as cleaning of the engine, grinding of valves and general examination. The second may include anything from a complete overhaul to a thorough rebuilding, according to the condition in which the engine is found when taken apart. Some operators give their engines only minor overhauls in the airport shop and have the complete overhauls done either at the plant of the engine builder or at some central maintenance base. This is by far the best practice. The first essential in the way of engine repair equipment is some means for lifting the engines into and out of the airplanes and moving them around the shop. Perhaps the most convenient and economical method is to use one of the smaller sizes of chain blocks for this work. The weight of modern airplane engines ranges about from 100 to 2,500 pounds, although those in most general use range between 200 and 1,000 pounds. It is not advisable to provide chain blocks having a capacity of less than 2,000 pounds, and still larger sizes, such as 3,000 pounds, are preferable. Of the three types on the market, differential, worm- and spur-geared, the latter is the most efficient while the first mentioned is the cheapest.

Tracks for Chain Blocks.

Where the funds permit, an overhead track for chain tackles should be installed in the engine shop to facilitate removing and

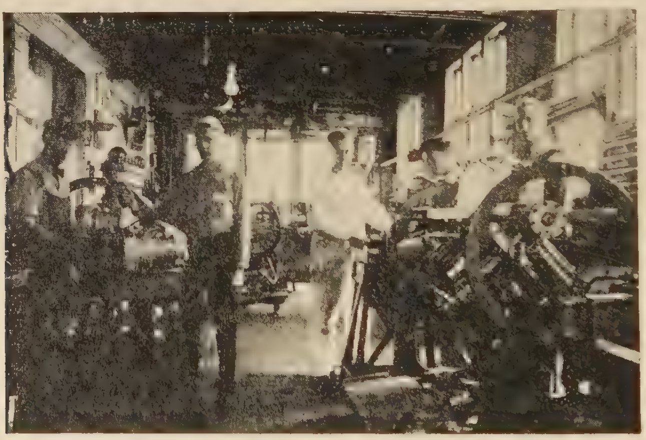


Fig. 43.—Motor repair and overhaul shop of Curtiss Flying Service, Garden City, N. Y. In the right foreground may be seen an "OX" engine on the overhaul and assembly stand.

replacing of engines and moving them around. Two kinds of track, the I-beam and the light pressed-steel type, are in general use for this purpose. Where the unsupported spans are short and there are few curves and switches, the pressed-steel track will be the cheaper to install. On the other hand, where there are long spans without intermediate supports,—the usual condition at airport shops,—the I-beam track will then become the cheaper. When tracks are installed they should be arranged so that the chain blocks may be used for lifting engines out of the airplanes, carrying them to the overhaul stands and to the test stands. The latter will usually require carrying the tracks outside of the buildings on special supports, which may be of timber or structural steel.

Engine Overhaul and Test Stands.

For complete overhauls of engines one or more engine assembly and test stands are essential. Several types of assembly stands are on the market and one of these, as shown in Figure 43, has been extensively used in both engine factories and maintenance shops. A stand of this type can be purchased for less than the cost of building a makeshift device. On the other hand, engine test stands are not available in the market and must be specially built. This type of stand is used to support engines during test runs at full speed with propeller or fan brakes. For ordinary work it is not necessary for the test stand to be provided with a torque brake, or other means of measuring horse-power, and it can be rigidly fastened down. The stand should preferably have adjustable engine supports which can be set to accommodate any engine likely to be tested. It should also be furnished with either a radiator or other water-cooling system where water-cooled engines are liable to be tested. In any case, there should be included gasoline and oil-feeding and measuring systems, tachometer, wire screen or other propeller guard and such pressure gauges as may be required for checking operation of the particular types of engines. An installation which may be regarded as typical for airport work is shown in Figure 44. The cost of these stands will vary with the materials on hand for their construction and they can often be built of discarded parts at nominal expense.

Miscellaneous Engine Tools.

Among the small tools, a number of special wrenches will be required for each type of engine to be received for overhaul and adjustment and a few machinist's hand tools will also be necessary. Several galvanized iron pans should be included for washing of engine parts in kerosene during overhauls. If extensive overhauls are contemplated, it may be found economical to install a pressure system for washing of these parts with a kerosene spray. A small bench arbor press, or lightweight floor press of the garage type or heavier, is a most useful addition to engine shop equipment and will save much time in disassembling and reassembling parts. The garage type of press has the advantage over the small, bench type that it can be used also for work other than engine repairs. For example, such a press would be of great assistance in the work of removing and replacing wheel bushings, etc. The bench type of press does not provide sufficient clearance for this kind of work. Several makes of garage force presses now on the market are suitable. Where force press equipment is provided, a set of gear pulling clamps should also be included as these items of equipment are frequently needed on the same classes of work.

Engine Jigs, Etc.

A jig should be built for checking of the ignition equipment of each type of engine where many are to be overhauled. Apparatus of this kind must be built in the maintenance shop and for each make of engine, as nothing in this line is on the market. The important feature in this ignition checking equipment is the provision of some means for checking operation of the distributors and for readjusting them on a "dummy" setup before they are reassembled with the engines. Line reamers for the main bearings of "in-line" types of

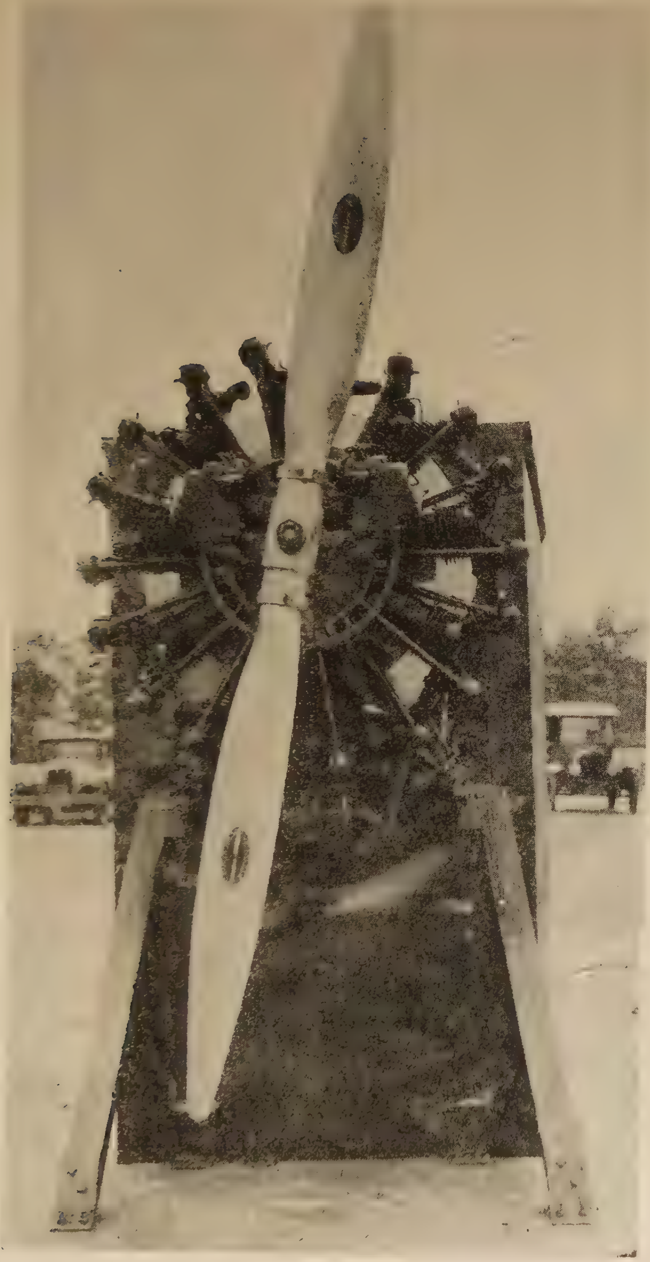


Fig. 44.—A Wright "Whirlwind" engine on the test stand used by Pitcairn Aviation, Inc. Stands of this type are used merely to give engines a short test run after overhaul.

engines will be necessary if this type is to be included in the work. In any case some suitable jig for checking the alignment of pistons and their connecting rods will be found always helpful and in the case of overhauls reaching any volume, very necessary. Indeed, where equipment of this kind is not to be furnished, it is desirable to send all major overhaul work back to the engine factory. Airplane engine main bearing line reamers are made by the Taft-Pierce Manufacturing Company, Woonsocket, R. I., and the Kirkham Products Corporation, Garden City, N. Y. Jigs used for checking alignment of pistons and their connecting rods should include some means for straightening bent rods, or tools for this work should be separately furnished. As airplane engine pistons and their rods must be very accurately balanced in sets before assembly into the engine, a suitable scale should be provided for this purpose. While any scale of precision class may be used, a special piston balancing scale is more convenient to use and a suitable type is made by the Toledo Scale Company, Toledo, Ohio, for this purpose.

CHAPTER X

FIRE PROTECTION OF AIRPORTS*

Fire Hazard at Airports.

"Airplane hangars,"—say the insurance underwriters,—"are seldom good fire risks." At many airports only a limited supply of water is available; a number of the buildings are of wood construction and the contents are always highly combustible. Most airplanes at present are built largely of wood and fabric, forming unequalled fuel for a fire to feed upon. Even should the use of all-metal construction become more general in the future, fire hazard will continue to be serious on account of the amounts of gasoline, oil, and other inflammable materials stored or being used in or near the buildings. It is therefore urgent that every precaution be taken, both in the original layout of the airport and in its operation, to: (1) prevent fire from starting; (2) limit its spread if started; (3) provide adequate means for extinguishing it.

Location of Inflammable Materials.

The first object can be attained to some extent by limiting the use of more inflammable materials to certain buildings and, in operation of the airport, strictly enforcing rules against the use of open flame lights, coal heating stoves, smoking and similar practices, in these buildings. If the use of blowtorches cannot be eliminated, at least they should be *lighted* outside of the building. The second object of limiting the spread of fire can be attained, in a large measure, by judicious spacing of the buildings. The dope shop, oil and paint storage house and other such buildings should be completely separated from other buildings on the field. Gasoline should be stored only in underground tanks whenever possible. The pumps for these tanks should be located at least 20 and preferably as much as 75 to 100 feet away from all other structures. Dope and other such materials should be stored in outhouses. The location of dope, gasoline pumps, paint and oil houses can easily be made both safe and convenient. The third object of the three cannot always be attained by adequate fire fighting equipment alone. Occasional fire drills will be necessary where operations are on a substantial scale. In all cases the installation of some type of fire alarm gong is desirable. This may be merely a hand-operated signal for small scale airport operations or may be a complete electrical alarm system in other cases.

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* Prepared with the cooperation of Geo. W. Booth, Chief Engr., National Board of Fire Underwriters.

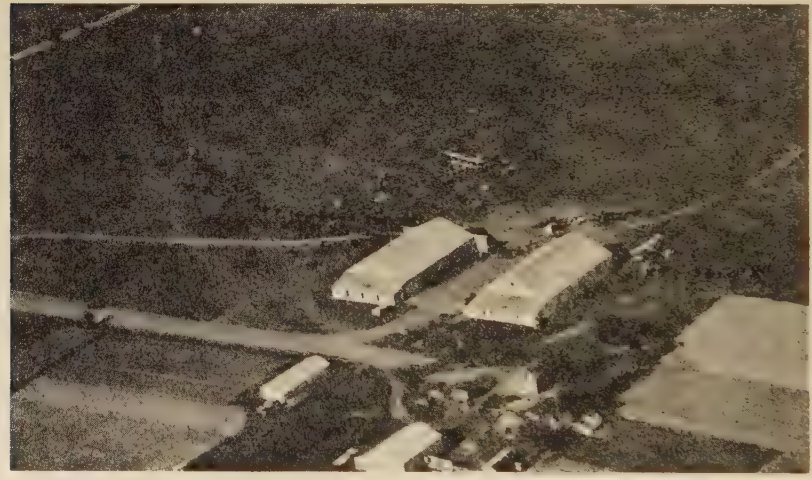

Fig. 45.—A corner of McIntyre Airport, Tulsa, Okla., showing liberal spacing of buildings for the purpose of reducing risk of fire spreading.

Fire Isolation.

Much can be done to prevent the spread of fire by liberally spacing the buildings in the original plan. A separation of twice the height is suggested, which would require that hangars be separated by some 40 or 50 feet. Some have even advocated increasing this spacing. It is usually a simple matter to arrange ample spacing and it has the additional advantage of leaving room for roadways or "aprons" between the buildings. This is good both from the viewpoint of convenience and from that of fire hazard. It is also suggested that the hangar and shop provisions be decentralized, to some extent, by use of a number of buildings of moderate size instead of a lesser number of very large ones. This advantage of reduced fire hazard must be balanced against the disadvantage of increased unit cost and less economical use of space for the smaller buildings. In the case of airports where hangars are to be leased to several different owners of airplanes, this decentralization becomes more important as individual owners are liable to be less careful than a well organized working force. In the case of air transport operators the fire precautions are likely to be enforced to a greater extent, hence the use of smaller buildings may become of less importance in reducing fire hazard.

Operating Precautions.

As little as possible should be left to be covered by operating practices and precautions. On account of the rather isolated position of airports and the infrequency of fire inspections some tendency toward lax enforcement of rules should be anticipated. It is therefore preferable to give more attention to fire prevention and isolation in layout of the field than to rely upon strict enforcement of rules during its operation. At the same time, every effort should be made to strictly enforce rules which are essential to reduction of fire hazard during the operation of the airport. If rules are limited to those absolutely necessary, less trouble will be encountered in their enforcement. Unnecessary rules (such as prohibition of smoking in buildings where it does not increase fire risk) only serve to create a general disregard of *all* rules. Perhaps the most important rule of all is one requiring that buildings be kept clean in the sense of being free from spilled oil, loose shavings, papers, rags and similar material. Fires usually start in untidy buildings. Metal drip pans should be used under engines where necessary to keep oil off the floors.

Gasoline and Oil.

Gasoline and other highly inflammable materials should not be handled in open containers inside of buildings. Where such materials must be handled inside of buildings, they should be kept in closed tanks of some type approved by the Fire Underwriters. Airplane gasoline and oil tanks should be filled either outside of buildings or close to the open door of a hangar, where they can be quickly removed from the building in case of fire. Oily waste, rags and such materials which are used in the buildings should always be kept in self-closing metal receptacles having legs at least 3 inches high and should be of a type approved by the Fire Underwriters. At the close of each working day the contents of these receptacles should be disposed of, or the receptacles themselves should be removed to outside of the buildings. Signs should be conspicuously posted, inside and outside of buildings as may be required, reading "No smoking in or within 50 feet of this building." Experience having shown the extreme difficulty of enforcing "no-smoking" rules in airport buildings, it seems preferable to allow smoking in all buildings where conditions warrant. This practice will increase respect for the rule prohibiting it in others.

Water Systems and Engines.

Where possible and when funds permit a storage tank and fire-protection water-distribution system should be installed with a hydrant located within reach of each building. The necessary hose should be kept in a box beside the hydrant, and it should always be maintained attached and ready for use. It seems barely necessary to point out that the whole system should be properly protected against freezing. Where the complete water system cannot be installed, as will be the case with many projects, a full equipment of portable fire extinguishers should be provided. The smaller sizes of chemical "engines" are most generally suitable for this purpose. Such apparatus should be located in outhouses, protected from freezing, and placed at strategic points on the field. No matter what other equipment is provided, some apparatus of the foam type should be on hand where there is any possibility of gasoline or oil fires. The foam extinguisher is, at present, the only thoroughly effective type for such use, although gasoline and oil fires *may* be put out with others. However, new types are under development, including those using carbon dioxide gas (CO_2) as an extinguisher, and give promise of being effective on gasoline and oil fires such as may occur at airports.

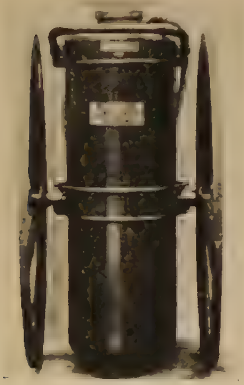

Fig. 46

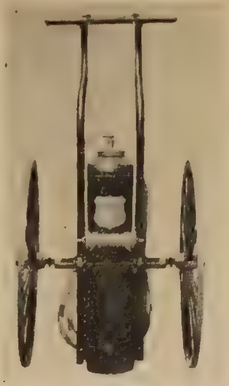

Fig. 47

Fig. 46.—American LaFrance 40-Gallon manual fire engine of the soda-and-acid type. Fig. 47.—"Foamite" type of manual fire engine suitable for airport use where not exposed to freezing. This type of fire extinguisher is particularly valuable in fighting gasoline or oil fires.

Visibility of Equipment and Instructions.

Hydrants, hose boxes, engine houses and all similar fire-fighting equipment should be located where plainly visible and should be painted a bright red. *It is most inadvisable to lock this equipment.* Where tampering is to be feared, the best practice is to fasten doors, etc., with an easily broken seal and to rely upon frequent inspection to detect interference. All fire apparatus should be plainly marked in large letters with such a legend as: "For fire use only." Concise instructions for use should be given on the apparatus itself and plans showing the location of the nearest hydrants, hose boxes, engine houses and other equipment should be prominently posted in *each* building. Absolutely nothing should be left to chance or to common knowledge of the force. It should be possible for an entire stranger to the airport to look around, locate the apparatus and put it into use without knowing anything about either it or the buildings. If this is not possible, then it is time to investigate the type of equipment or its location.

Hand Extinguishers.

All buildings should be fully equipped with reliable hand fire extinguishers *of the type most suited to the particular conditions,* as shown in Appendix 7. Each building, no matter how small, should be supplied with at least one hand extinguisher. While the total number will depend upon the contents of each building, it is recommended that the following be considered good general practice:

Allowance of Hand Fire Extinguishers:

2½ gal. size of soda-and-acid, foam, or calcium chloride type.	1 to 2 for each 2,500 sq. ft. of floor space.
1-qt. size of carbon tetrachloride type.	1 to 2 for each 1,000 sq. ft. of floor space.

The higher allowances are recommended for buildings where highly inflammable materials are used or where the additional protection of engine equipment is not available. The smaller allowances may be used for offices, or for shops which are also protected by engine or water-supply equipment. These allowances provide somewhat more equipment than necessary to meet the minimum insurance requirements, but the special conditions which have to be met at civil airports make this increase advisable.

Placing of Extinguishers.

If extinguishers located inside of the buildings are not placed with some judgment, they may be useless in case of fire. Each room, with the possible exception of small offices, toilets and such, should be allowed at least one extinguisher. Every possible source of fire should be studied and one of the extinguishers placed where conveniently available in case of fire from that source. All extinguishers should be located so that those going for them will not be subjected to personal danger. For this reason it is advisable to give preference to locations near exits. Where possible, the extinguishers should be distributed around rooms so that one is always within convenient reach of any point in the room. They should never be placed close to each other where avoidable. When hung on walls or columns the lifting handle should not be over 5 feet from the floor, to facilitate their removal. There is a marked tendency to place the 2½-gallon size of extinguisher too high for quick removal. As every second may count, this feature cannot be ignored.

Freezing Considerations.

Types of equipment subject to freezing should be located with due regard to this danger. The ordinary soda-and-acid type and the foam type are each subject to freezing at about the same temperature as water. The carbon tetrachloride types generally contain materials which are added by their manufacturers to prevent freezing at all ordinary temperatures. The calcium chloride solution types are also non-freezing. Just as with the fire hydrants, all hand equipment should be made plainly visible. Where each extinguisher is hung, a bright red background should be painted on the wall, post, or other support. Another satisfactory method of increasing the visibility of extinguishers is to paint the apparatus itself a bright red and the background, against which it hangs, a bright yellow or white. The best method for each installation will depend upon the color of the surroundings.

Selection of Types of Extinguishers.

Every type of extinguisher has its good points and its poor ones. The most effective in certain cases may be useless in others, and this should be taken into consideration when the equipment is selected. Most types on the market are almost useless for extinguishing gasoline and oil fires. For combating these the foam extinguisher is the only thoroughly effective type as yet in use, although, as mentioned previously, other promising types are under development. Unfortunately, the foam extinguishers freeze unless protected from cold. Where the oil-fire danger is present and the foam type cannot be protected from freezing temperatures, the carbon tetrachloride type should be substituted. No other of the existing types should be considered of value in fighting gasoline and oil fires. In selecting carbon tetrachloride types it is well to keep in mind that there is a slight element of danger in using these in confined quarters on account of the irritant gas (chlorine) released when the liquid is broken up by heat. Where there is any possibility of electric fires only the carbon tetrachloride types should be provided, as this extinguisher is the only one making use of a liquid which is a non-conductor of electricity. Pails of sand are of some value for extinguishing electric fires, as well as some other fires, but their use is limited and they should be considered merely as auxiliaries to chemical-extinguisher equipment. Sand is nearly always available cheaply, and it is just as well to distribute pails of it throughout the buildings in addition to the other equipment. These pails must be kept dry, as wet sand is practically useless for putting out fires. The pump-tank type (consisting of a portable tank emptied by means of a hand pump) is another extinguisher of value for airport use. This type is made in 2½- and 5-gallon sizes.

Inspection and Recharging.

All fire equipment should be inspected about once a month and the record of each inspection kept on an indestructible cloth tag attached to each piece of apparatus. Soda-and-acid, calcium chloride and foam extinguishers should be washed out and recharged once each year though apparently in good condition. Carbon tetrachloride extinguishers need not be recharged if full, but their operation should be tested to make sure that the apparatus has not become corroded. When this type is being recharged, ordinary carbon tetrachloride should never be used in place of the specially treated liquid. All extinguishers should be cleaned and recharged with the proper materials immediately after use, and spare charges should always be kept in stock for this purpose. All of this inspection and recharging should be done under the supervision of the airport management instead of being left to tenants of leased hangars. A standing rule should be made, *and strictly enforced*, requiring a report to the field manager of any use of fire equipment, no matter how slight it may be. Where a monthly inspection shows unreported

Fig. 48.—A night view at the Oakland, Calif., Municipal Airport.

use of equipment, this should be investigated at once. Many fire extinguishers, more particularly the small carbon tetrachloride ones, are popular among those inclined to horse-play, and their use for this practice might cause the buildings to be left without adequate protection in case of fire. The requirement of a report of all use of the apparatus, combined with its sealing, will do much to discourage use of fire extinguishers for horse-play.

CHAPTER XI

Special Requirements of Seaplane Bases*

Types of Bases.

Many of the factors to be considered in selection and arrangement of seaplane bases are similar to those of airports for landplanes. However, certain special needs must be allowed for, and these will be covered in the present Chapter. Seaplane base locations may be considered as in two classes: (1) those located on some river, small lake or other body of water which is tolerably free from heavy swells; (2) those located on the shore of either an ocean or extremely large lake where the surface is never smooth and where a sheltered location is desirable for taking off or landing. In the first case it is best practice for pilots to take off and land some distance out from the shore and to "taxi" towards the beach. This policy reduces the danger of colliding with any surface craft or running up on the beach at high speed. On the other hand, in cases where the surface of the water is normally rough a different policy may be necessary.

Where Sheltered Areas Are Desirable.

When selecting sites for the second type of bases it is therefore desirable to consider the possibility of locating on the shores of a small bay or other partly protected body of water. Thus the pilots can take off from or land on a comparatively smooth surface and risk of damage will be decreased. Of course, the best water condition for safe landing is one in which the surface is neither "glassy" in smoothness nor so rough as to violently buffet the seaplane about. All sheltered areas of water become glass-smooth in dead calm, and at times pilots experience a little difficulty in estimating their altitude when landing. In all cases the water area must be normally free from floating driftwood liable to damage seaplane hulls. It is also desirable that the area adjacent to the seaplane base and operating area be as free as possible from bathers or swimmers and from surface traffic such as small boats. Operations should never be located where exposed to these interferences, lest accidents result.

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* Prepared with the cooperation of Walter Hinton of the Aviation Institute of the U. S. A. and who piloted the NC-4 on the first trans-Atlantic flight.

Operating Area.

The area of water required for landing and taking off depends upon the types of seaplanes, altitude above sea level, surroundings of the airport and other such considerations. For types of seaplanes in general use today and for sea level, this area should never be less than 3,000 to 4,000 feet long by 1,000 to 2,000 feet wide. Even greater area is desirable, and in some cases it may be necessary. The operating area of water should be so orientated that the long dimension lies in the direction of most frequent take-off. Desirable width is greatly affected by the amount of variation in direction of winds and the greater the variation the greater will be the width required, up to the point where the area is approximately round in shape. The width should be sufficient to enable the pilot to take off or land directly into any wind of over 8 to 10 miles per hour with a clear surface of at least 3,000 and preferably 5,000 feet. It is perhaps well to remark here that seaplanes usually require more space than landplanes in which to take off or land.

Surroundings and Depth of Water.

Just as with flying fields, the surroundings have an important bearing upon the area of water used in seaplane operations. Thus where the operating area is bounded by shore lines these should be free from high obstructions or sudden rises in elevation. Otherwise, the obstruction must be regarded as rendering useless a part of the water surface adjacent to it and for a distance of about 8 to 10 times its height. All water surfaces used for taking off, landing, mooring or taxi-ing should be absolutely free from floating, sub-

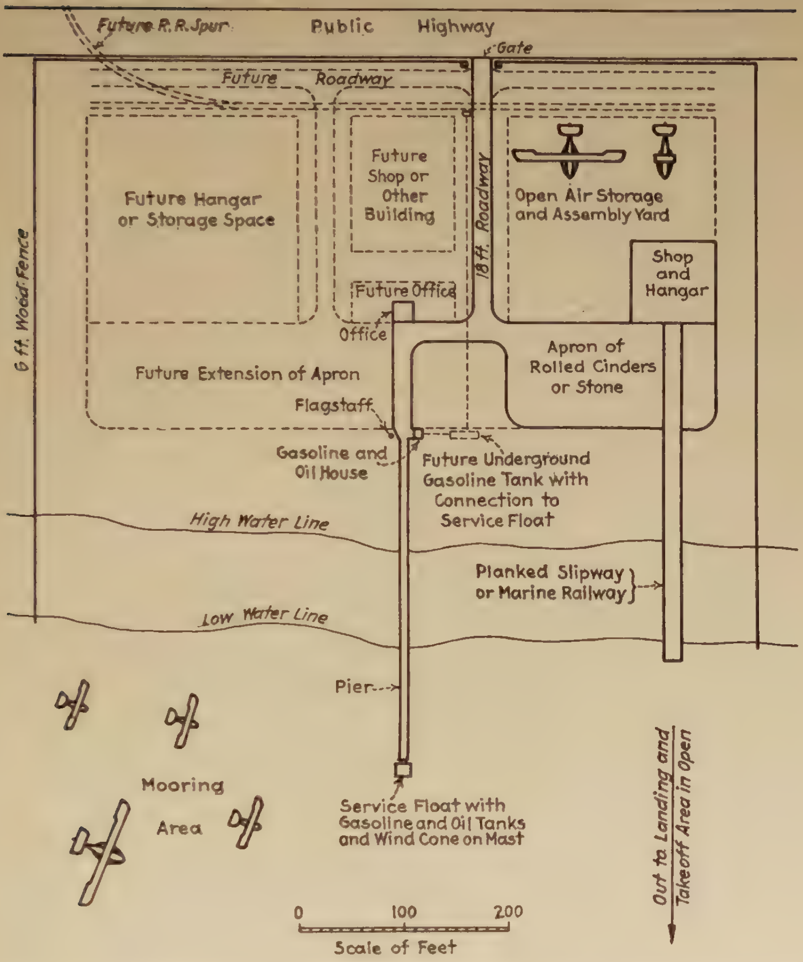
Future R.R. Spur
Public Highway
Gate
Future Roadway
Future Hangar or Storage Space
Future Shop or Other Building
18 ft. Roadway
Open Air Storage and Assembly Yard
Shop and Hangar
6 ft. Wood Fence
Future Office
Office
Apron of Rolled Cinders or Stone
Future Extension of Apron
Flagstaff
Gasoline and Oil House
Future Underground Gasoline Tank with Connection to Service Float
High Water Line
Planked Slipway or Marine Railway
Low Water Line
Pier
Mooring Area
Service Float with Gasoline and Oil Tanks and Wind Cone on Mast
Out to Landing and Takeoff Area in Open
0
100
200
Scale of Feet

Fig. 49.—Arrangement of a seaplane base for civil use. Hangar needs will vary greatly in accordance with elements discussed in detail in the accompanying text.

merged or projecting obstructions. A depth of about 6 feet is sufficient to provide draft for any present-day seaplane, while 3 feet is ample for smaller sizes. The airport rating regulations of the

Department of Commerce specify a minimum depth of 6 feet at any time as necessary to obtain the highest rating. It is always desirable that water areas used by seaplanes be free from strong currents.

General Plan of Base.

A suitable arrangement of a seaplane base without landplane facilities, and such as would be used for civil purposes, is shown in Figure 49. In this particular plan considerable allowance has been made for future expansion, a policy which should be adopted where local conditions permit. If provision for expansion is not to be considered, the grounds could be cut down to a small portion of the area shown. Whether or not this would be wise depends greatly upon the number of other possible sites to which the airport could be moved as it developed. The buildings, seaplane ways or marine railways and other equipment should be located on the beach at one side of the stretch of water which is to be used for operations. In other cases where this is not practicable they might be located on some other nearby beach which is connected with the operating area by a channel of a width equal to at least five times the wing span of the largest seaplane likely to be used. For seaplanes in use today this width should thus be at least 250 feet and preferably about 600 feet. It is also desirable that this connecting channel be not over 500 to 1,000 feet long or excessive taxiing becomes necessary. In no case should the buildings and other facilities be located directly in the path of normal take-off or landing. The hangars should be sufficiently above the high-water level to permit turning of seaplanes on the apron in front of them while the tide is in. Space on the surface of the water should be assigned for mooring purposes, preference being given to a somewhat sheltered location.

Service Float and Equipment.

It is practicable to use seaplane ways also as a landing stage for passengers and cargo, but where this is done the ways must be carried some distance into the water, and a service and landing float must be provided which does not interfere with movement of seaplanes being taken in or out. It is usually easier to provide a separate landing stage. Either a service float should be provided with oil- and gasoline-supply tanks or a small power boat should be so equipped. This power boat is a useful addition in any case, and where many passengers are to be carried it may become an essential. Tanks in service floats or supply boats should have measuring pumps operated by hand or power to facilitate servicing of seaplanes while out on the surface of the water. Provision of a wind cone or other wind indicator is also desirable and is required for Department of Commerce rating, although not of such vital importance as in the case of flying fields. In many cases where landings and take-offs are made out in the open at some distance from the base this indicator will be so far away that it cannot be distinguished by the pilots. The direction and velocity of the wind can usually be gauged by pilots from observation of the surface waves or ripples without any other means. The general facilities such as lighting, telephone, roadway connection, fresh water supply, transportation and other needs are much the same as required in landplane operations. However, a railroad connection is often of less importance in the case of seaplane bases where transportation by water can take the place of rail.

Seaplane Handling Facilities.

To facilitate handling of seaplanes between hangars, shops and the water, an arrangement of aprons and inclined ways or a marine railway will be necessary. Aprons should be of concrete, but rolled cinders or broken stone can be used if necessary. The launching ways may be of either concrete or wood, the latter being perhaps the most generally used. The incline of seaplane launching ways should not be more than 10 degrees where practicable, and in no case should it exceed 15 degrees unless power equipment is provided for hauling out. The figure of 20 degrees proposed in some publications is considerably too high and great difficulty would be experienced in service. If the seaplane ways are moderate in grade it will be possible to haul fair-sized craft out of the water without the assistance of mechanical equipment. Where the seaplane power plant can be operated to assist its movement, even the large types can be hauled out in this manner. All launching and hauling-out facilities should be carried sufficiently below low-water level to permit their use without depending upon tides. In constructing seaplane ways of considerable length and with limited funds it may be found economical to use rolled cinders or stone for the parts above high-water level and to use concrete or wood only for those parts which are below water at times.

Construction of Seaplane Ways.

In constructing seaplane ways of wood, two or more rows of piles are driven into the sand; beams are set on edge on these and securely spiked to them. The beams are then planked with two layers of stout, rough lumber planking, the layers being run at an angle to each other. Both may be laid on the bias, in opposite directions, or one may be laid on the bias and the other across the path. Planking should never be run parallel to the center line, as this

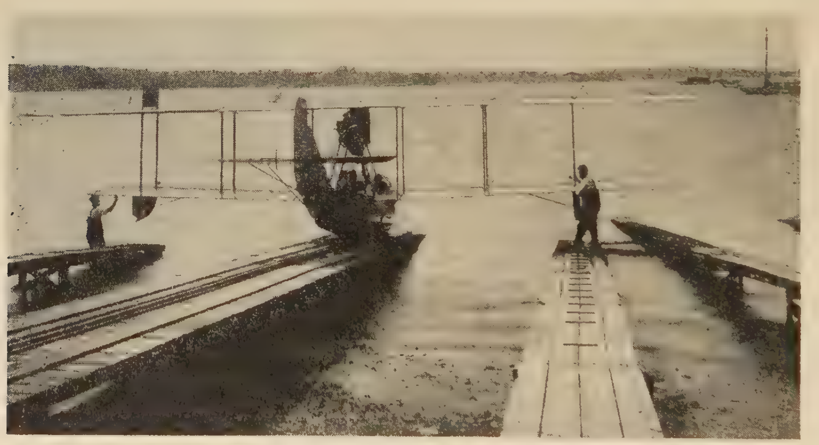

Fig. 50.—Arrangement of launching ways, for small and moderate sized seaplanes, with walkways at each side for the use of men guiding the wings. The seaplane shown is a Curtiss "Seagull," a type produced shortly after the war.

weakens the construction and tends to loosen up the structure. The width of seaplane ways, which determines the number of rows of piles required to support them, depends upon local conditions. If the surface is approximately level with the beach for the entire length of the way, they may be made only a few feet wider than the tread of the truck wheels or, say, 6 to 10 feet, depending upon the size of seaplanes. In cases where the surface is appreciably above the level of the beach it may be necessary to widen the ways enough to provide walkways for men guiding the wings. In some cases this provision is made by building two light and narrow walkways on each side of the seaplane ways. If only the smaller types of seaplanes are to be used it may be possible to utilize a very simple wooden track, as shown in Figure 51. In this case ways, handling trucks and mechanical means for hauling out can be dispensed with. For the larger types, however, either a marine railway or ways and some mechanical means for hauling may be necessary. As pointed out in a previous Chapter on equipment, small crabs, winches, capstans or creeper tractors are suitable for this purpose.

Marine Railways.

In cases where operations are to be on a most substantial scale or where the largest types of seaplanes are to be handled, it may be necessary to install a regular marine railway using steel rails in place of the single wood track or the launching ways. An excellent arrangement for a marine railway can be obtained by constructing a concrete ramp from the hangars down the beach to form a platform level with the top of the marine railway car at a point just above the high-water line. From here the railway runs down to well below the low-water line. The marine railway car should be flat topped to receive the seaplane and of heavy construction so that it will remain on the track while under water. In using this equipment the seaplane is either provided with its own wheels or a wooden truck with wheels is floated out to meet it. The seaplane is then worked on to the submerged railway car and the hauling apparatus started. When the car reaches the end of its run the seaplane is rolled off onto the platform forming the end of the concrete apron. With equipment of this type the hauling must be done by mechanical means, and where the beach is nearly flat the car must be hauled into the water also. An electric motor winch is very convenient, but a good hand winch is much cheaper and almost as good, while a gasoline tractor is probably the most generally useful of all.

Building Requirements.

Building needs are affected not only by the number of seaplanes to be accommodated at the airport but also by the proportions of these which are to be moored out on the surface of the water, stored on shore in the open and kept indoors in hangars. It is not always practical nor is it always necessary to provide hangar space for all of the seaplanes and to figure on hauling these out of the water every day. In many cases buildings are provided only for storing a part of the active fleet, on the assumption that seaplanes will be moored out on the water for the major part of the time and placed in the hangars only while undergoing repairs or for storage. The inconvenience of hauling large seaplanes out of the water daily causes many operators to leave them afloat until it becomes necessary to take them out of service for storage or repairs or to lose some of the water absorbed by wooden hulls. In every case repair-shop and office space should be provided, and it is desirable that the shop building be capable of housing the larger types of seaplanes and so placed that they can be hauled up into it when necessary to repair hulls. Where the airport is located in a northern climate it may be necessary to suspend operations during the winter when the water freezes over. In such cases the seaplanes may be stored, preferably in hangars or otherwise out in the open under tarpaulins. Where stored in buildings, the wings may be removed to allow more efficient use of space. Seaplane hulls which are constructed of wood must never be stored in heated buildings for any length of time, as this causes deterioration, and all of these points must be considered in planning the buildings.

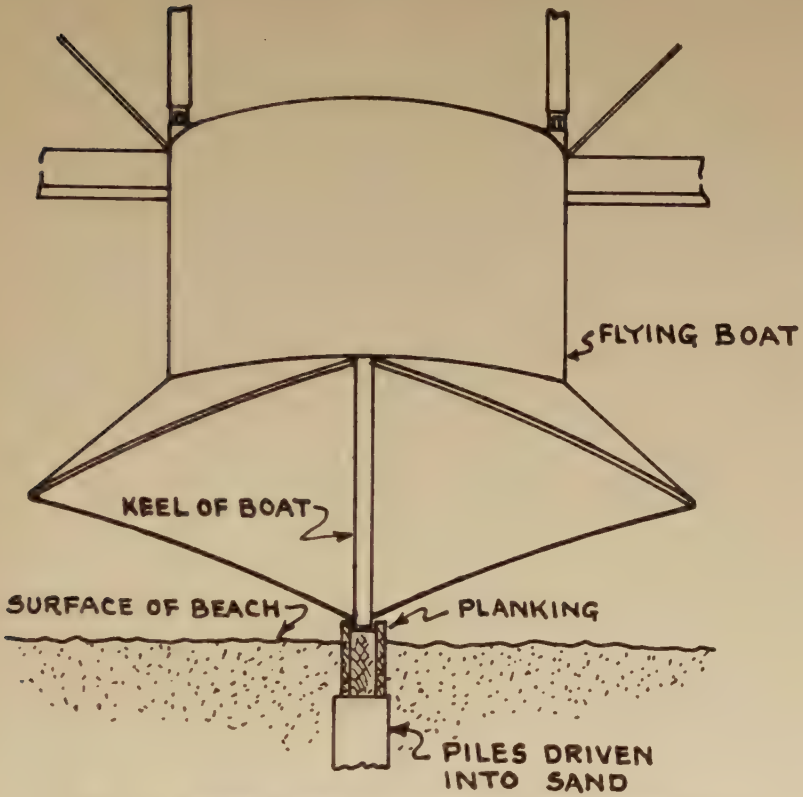

Fig. 51.—A simple launching railway for small flying boats and single-float seaplanes.

Mooring Facilities.

Whether or not seaplanes are to be hauled out every day, ample water space must be assigned for mooring use and the necessary facilities in the way of anchors, buoys, etc., provided. The mooring space should be selected so that seaplanes and flying boats left there are out of the way of others landing, taking off, or maneuvering. The most satisfactory methed of mooring seaplanes is to provide pick-up buoys either of cork or of iron which is covered with a rope net to prevent accidental damage to the seaplane hull.

These buoys are used to hold and mark the ends of the mooring ropes, the other ends being fastened to anchors, rocks, or similar sunken weights. To facilitate the picking up of mooring ropes without danger of striking the pick-up buoys it is often desirable to provide also small "messenger" buoys connected to the main buoys by a 15- or 20-foot line. In picking up mooring the seaplane is then kept at a little distance from the main buoy, and the messenger buoy is lifted aboard when it is reached. All of these buoys should be painted white to prevent confusion with conventional colors used for aids to navigation. Care must also be taken that no buoys are located in a position where aircraft moving over the surface at high speed may come into contact with them. The mooring area should therefore be clearly defined either by its natural arrangment or by the use of painted marker buoys. Mooring should always be effected by the use of buoys or anchors and stakes or piles, whether submerged or projecting, should never be used for this purpose.

Night-Flying Equipment.

The question of night-flying equipment will be taken up at some length in the Chapter on that subject, but some references are necessary here with regard to the special requirements of seaplane bases. Up to date most night flying has been confined to overland operations and to land planes; hence we have not the same wealth of experience to draw upon in considering night operation of seaplanes. However, some generalities can be made from what knowledge is available. To provide the necessary light for working on seaplanes, launching or hauling them out, at least two floodlights of the outdoor, portable type should be available on the beach. To facilitate servicing of machines at night, there should be a fixed white light at the end of the pier or on the service float and a lighted buoy or buoys should be arranged so that incoming pilots can use them to judge their height and position when landing. Some floodlighting equipment, for use in taking off and landing, should also be available, as for landplane operations.

Riding Lights and Obstruction Marking.

To avoid collisions, moored seaplanes must be provided with riding lights of some type in accordance with the Department of Commerce regulations, and these may be arranged by using portable lanterns if the moored machines are not equipped with permanent lights. The regulations require a green light on the right wing, a red light on the left one and a white light on the tail (each with specified angles of visibility) for airplanes in operation. Seaplanes anchored or moored "in navigation lanes" are required to carry a single white light which is commonly termed the "mast head" light or anchor light and which is usually located just over the center of the upper wing. Just as with flying fields, all of the obstructions surrounding a seaplane base should be marked by obstruction lights, but in the case of the seaplane base this should include those on the water as well as those on land. While land obstructions may be marked with *red* lights as at flying fields, those on the water must be marked with *white* lights to accord with established marine practice.

CHAPTER XII

REQUIREMENTS OF AIRSHIP AND BALLOON STATIONS*

By RALPH H. UPSON,

Airship Engineer and Originator of the Metalclad Airship.

Airplane and Airship Requirements.

In view of the development of commercial airships for handling of heavy traffic over the longer air routes, it is important that their needs be taken into consideration in formulating plans for any important airport. Viewed from a practical standpoint, the commercial air*plane* service consists usually of three main elements: (1) the airplanes; (2) the airway with its beacons and intermediate landing facilities; (3) the terminal airports. The air*ship* service, on the other hand, is relieved from the necessity of providing for intermediate landings along the course and beacons become of secondary importance in their navigation. Hence the airship service considered of itself requires no fixed route and consists of only: (1) the airships, and (2) the terminals. These airship terminals are of various types in accordance with the use to which they are to be put and may be grouped into three general classes: (1) simple traffic stops or "ports of call" requiring only mooring apparatus and incidental facilities; (2) maintenance stations having hangars or sheds available for storage or repair of airships; (3) construction stations with facilities for fabrication and assembly of airships. Usually, the second class will include also the functions of the first, while the last may combine the functions of all three. As this volume deals with airports rather than with construction plants, the third type of airship station will not be taken up here, except to point out that it represents a most efficient combination.

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* Including some excerpts from a paper on this subject presented before the Metropolitan Section, American Society of Mechanical Engineers, New York, February 11th, 1927.

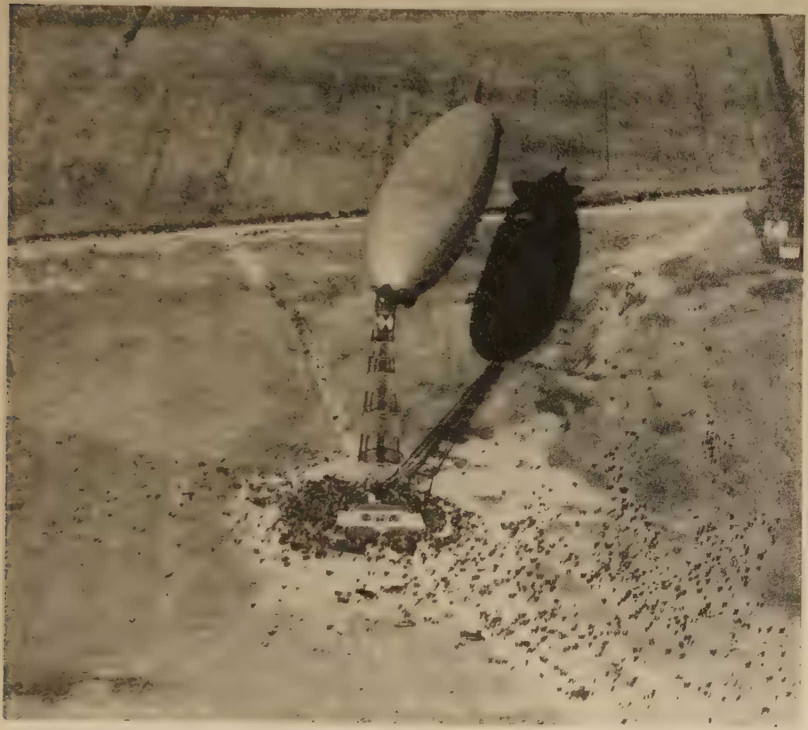

Fig. 52.—The rigid airship Los Angeles moored to the tower at Ford Airport, Dearborn, Mich. The size of the airship and the tower are vividly illustrated by comparison with the crowd of people on the ground. Note the alternate black and white painting of the tower to increase the visibility. (Photo, Kalec & Forster).

Airship "Ports of Call."

In most cases where airship facilities are to be given consideration in civil airport projects, the stations will fall under the first type in the above list. From the airship point of view its function will be that of a mere stopping point for taking on, discharging or transferring of passengers, mail or express packages. Efficiency in the operation of airships depends largely upon their ability to travel long distances without a stop, as contrasted with the airplane which must come down to replenish its fuel every few hundred miles if a practical "pay load" is to be carried. Hence airship operation entails long-distance operation with few stops, and this, in turn, necessitates a feeder system (most logically airplanes) for concentration of the traffic at the airship port of call. Thus every airship stop will have the importance of a terminal at which both airplanes and airships must be provided for. To put it in other words, it is not necessary that every airport have airship facilities, but it *is* necessary (with some few exceptions) that every airship port have also airplane facilities. As the needs of the airplane, rather than those of the airship, will usually determine the size and type of airport, and, as these have already been discussed in previous Chapters, only the items of equipment peculiar to airship operation will be taken up here.

The Question of Airship Mooring.

In airship stations of the first type,—those which are simply ports of call,—the outstanding necessity for their reception is some means of mooring. The development of mooring facilities is closely tied up with the development of the airship itself. It is obvious, for example, that any method of outdoor mooring will be economically sufficient only in proportion as the airship itself is durable when exposed and of sufficient strength to resist atmospheric forces. The original German system was to provide shed capacity for every airship at each regular stop. This not only involved large building cost but required a large ground crew,—150 or more even in good weather,—to house the ship, an operation which became practically impossible in a side wind of more than about 15 miles per hour. Any attempt to moor outside in a fixed position would be open to the same objection. With the airship parallel to the wind the condition is quite different, the resistance in this case being less than 1/40th of what it is when transverse to the current. Obviously, a modern airship designed for an air speed of 70 to 100 miles per hour, with proper factors of safety, need have no fear of winds of similar magnitude while moored near the ground *if the winds are always approximately head on* as when in flight. The essential function of the mooring mast is to accomplish this in practice.

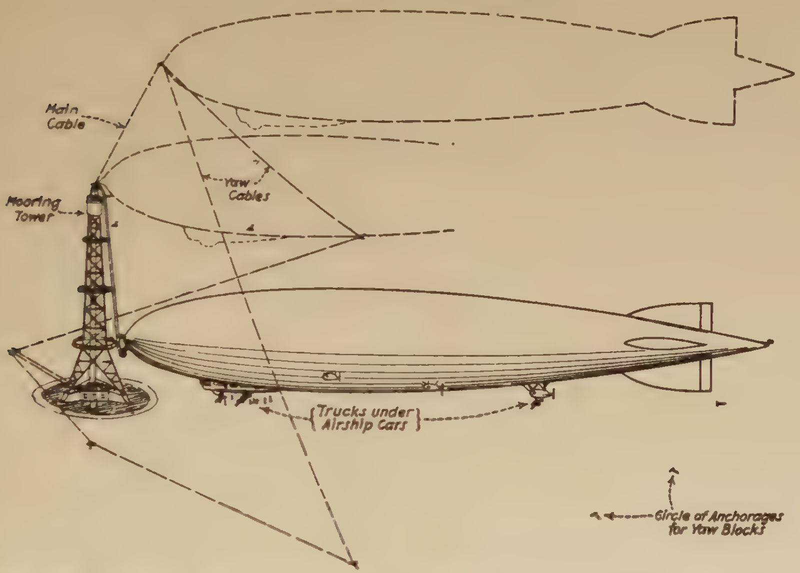
Main Cable
Mooring Tower
Yaw Cables
Trucks under Airship Cars
Circle of Anchorages for Yaw Blocks

Fig. 53.—Sketch of the mooring, hauling-down, and anchoring system of the airship tower designed and erected by the Aircraft Development Corporation at Ford Airport, Dearborn, Mich. (For Photo of the tower in use see Fig. 52).

The Mooring Mast.

Credit for the origin of the mooring mast has been variously claimed in England, Germany, Italy and the United States. The first known publication seems to have been in the United States*, but England was the first country to realize its possibilities and to actively push its development. As now used, the mooring equipment consists of the mast or tower itself and a circle of yaw-block anchorages set into the ground around it. In effecting a mooring the method shown in Figure 53 is used. Three lines are dropped from the nose of the airship; one is coupled to a line dropped from the top of the tower, while the others are passed through blocks attached to the proper anchorages on each side of the airship. The slack in all three lines is then taken up and the hauling down starts, the airship being trimmed "light" so that it tends to rise and thus keeps all three lines taut. The actual hauling down is carried out by means of the center line, which is coupled to the tower, and the side or yaw lines are used to control forward and side movement of the nose by holding back against the pull of the center line. The length of the yaw lines is also adjustable to swing the airship nose down to the mooring point as the main line is pulled in. When the nose of the airship finally engages the coupling device at the top of the tower, it is fastened in place and the process is complete. Loading and unloading is usually accomplished by means of a gangway running from the forward part of the airship (near the nose) to the upper part of the tower and free to rotate with the ship as the wind changes. Inflation gas, fuel and water are usually supplied through pipes carried up in the tower and designed for coupling to the airship.

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* The Aerial Battleship, Carl Dienstbach and T. R. Macmechen, *McClure's Magazine, August,* 1909.

Modifications of the Mooring Mast.

While there are many possible modifications of the present mooring mast, all have the same essential function of directing the airship approximately into the wind. The two principal variables are in the means used to control horizontal and vertical movements of the ship while moored. Turn-tables and other mechanical means have been proposed for controlling horizontal orientation, but the complication does not seem justified in view of the proven effectiveness of merely allowing the ship to find its own position headed into the wind. The means of controlling vertical movements or "trim" seem to offer more possibility of improvement. Horizontally the wind may vary through the entire 360 degrees; hence safety requires free movement of the ship through this same range. In the vertical plane conditions are reversed. The wind does not depart seriously from the horizontal over a level field, but where there is little or no wind, static forces or a sudden reverse gust may cause a dangerous change in trim. Therefore it is desirable to keep the ship at all times as nearly horizontal as possible. This is usually accomplished by such means as: (1) use of the airship elevators; (2) moving of ballast; (3) dragging devices on the ground; (4) movable ground connections for holding the airship at or near the horizontal position while permitting it to swing around the mast as the wind changes.

Ford Airport and Scott Field Masts.

The mooring mast is not yet entirely out of the experimental stages, although several thoroughly practical designs have been constructed in various countries. The first mooring mast ever built was erected in England, and the first American mast was constructed at Lakehurst (N. J.) Naval Air Station. The Aircraft Development Corporation of Detroit has been at work on the subject for several years and has constructed two masts or towers embodying some original and unusual ideas. The first of these, the Ford tower at Dearborn, Mich., has, in addition to the regular mooring connections at the top, a guide rail by means of which the airship may be lowered to the ground and held down by weighted cars so that the ship is still free to rotate with the wind. The new U. S. Army tower at Scott Field, Belleville, Ill., and the second of the two referred to, has no hauling-down mechanism, but represents a distinct advance in general construction. This tower is of circular section, being entirely enclosed with steel plating and having no outside guy wires or girders. The crew necessary at a tower of this type is only about 12 men, distributed between the tower, the winch house and the ground. An experimental type of mast (termed the "stub mast" because of its short height) has been tried recently at Lakehurst, N. J. This type has some decided advantages, but it also has certain disadvantages, more particularly when used with the very long, slim type of airship still in vogue. In foreign countries the greatest interest in mooring mast development seems to have been shown in England, where (as stated previously) the first practical mast was built and where development has been continued steadily.

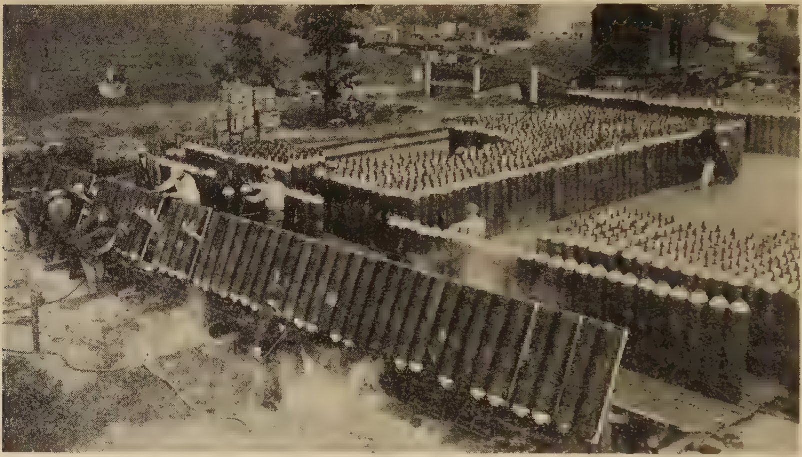

Fig. 54.—Piping fuel to the Graf Zeppelin at Lakehurst, N. J. (Wide World Photos).

Lighting for Night Operations.

At airports where both airships and airplanes are to be operated, the lighting equipment for night operations will be governed largely by the requirements for airplanes, which will be discussed at length in the Chapter on Lighting. Obviously, both the mooring tower and an airship moored thereto should be marked with lights to eliminate danger of having some airplane collide with them. Lighting systems should be provided on the tower as may be necessary to facilitate the work of mechanics engaged in night mooring. Frequently batteries of floodlights are arranged on the mooring mast to illuminate the area around it during night moorings. The proper pair of blocks on the ground for securing the yaw lines are marked by green and red lights to indicate starboard and port respectively, while the main coupling party (of two or three men) between these points carries a white light. A flare or smoke candle is generally used to show the direction of the wind and signals are transmitted by waving lanterns or some other flashing means.

Sheds.

As pointed out earlier in this Chapter, for an airship of adequate strength and durability, hangars (or sheds as they are more often called) are required only at stations where repair or construction work is to be carried on. Indeed, the mooring of airships close to the ground (by use of a haul-down or a stub mast) may eliminate the need for sheds excepting for major repairs, overhauls of the structure and for new construction. Before the days of the mooring

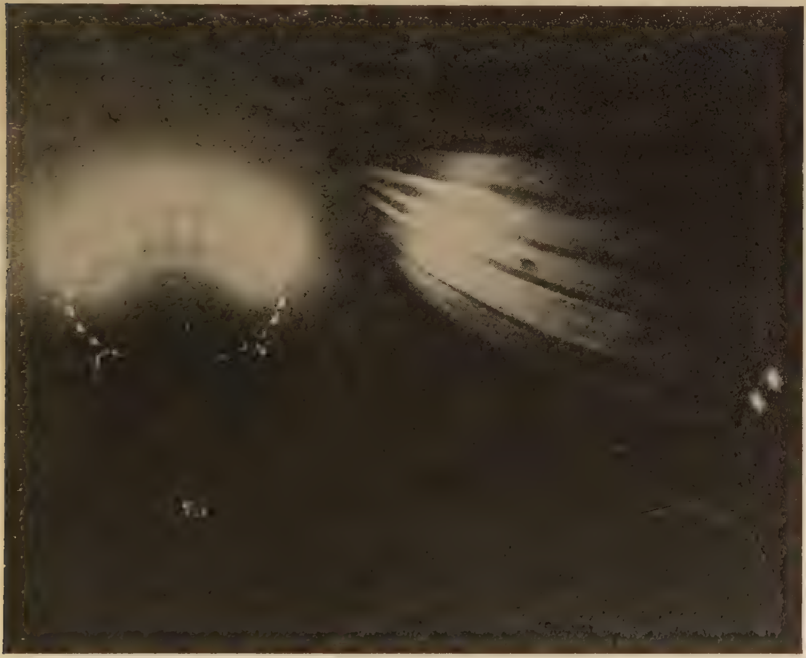

Fig. 55.—Effecting a night mooring to the Lakehurst, N. J. mast. Just below the platform at the top of this mast are two circles of twenty-four 1000-watt projectors, used to illuminate the area around the mast to a radius of about 1000 feet. The platform itself is lighted and marked by means of six other lights.

mast, the problem of getting into a shed in a side wind was so serious that the Germans mounted some of their sheds on turn-tables or floated them on the water, where they could be turned in line with the wind. The more recent sheds, such as at Lakehurst, N. J., and at Scott Field, Ill., have been built in a fixed position but with doors at each end. This present tendency has been carried still further in the case of the shed of the Aircraft Development Corporation at Grosse Ile, Michigan. This building has provisions for an airship door in one end only, the end opposite the prevailing wind, and the whole building is set in the margin of a thick woods which forms an excellent wind screen. As regards the size of hangars, it is necessary to give much consideration to future changes in the size of airships. There are no "standards" for the size of airship sheds as there are for airplane hangars and designs are created to meet the requirements. A good policy is that of constructing a building of sufficient length to house the airship considered, but of substantially greater width and height than necessary. Thus the building may be made large enough to accommodate a future and larger airship by merely adding some sections to its length. This is all the more important in view of the present tendency toward airships of proportionately larger diameter.

Shed Construction.

The earliest sheds were constructed wholly of wood, but increase in the size of airships soon made it necessary to adopt steel for the trusses. Today, most sheds are constructed on a steel framework and sheathed with corrugated sheet steel, sheet asbestos or wood siding. Two sheds, constructed wholly of concrete, have been built at Orly, France. Good ventilation under control is desirable and this is usually attained by provision of a ventilating monitor or series of ventilators running the full length of the roof. Windows should be liberally provided in both sides, the roof and even in the end doors and all of the window glass should be yellow tinted to protect the airship fabric cover from the action of sunlight. It is not usual to heat the shed proper on account of the great cubic capacity, although otherwise desirable. Local heating by means of radiant electric units, with large reflectors, has recently been used with success at Grosse Ile. Shop and office facilities are generally provided by constructing low buildings along one or both sides of the main buildings either inside or outside. These may, of course, be heated. Lighting of these buildings is usually by large protected incandescent electric units suspended near the ceiling and mounted on the side walls. Outlets for extension lights and electric hand tools should be also provided along the side walls. Other major requirements include gas and water connections, walkways along the sides and top, mooring rings, etc. The great size of the doors of airship sheds makes it necessary to operate these by power (in all excepting the smaller sheds) and the large area of these doors makes it necessary to give unusual attention to wind bracing.

Handling Rails.

Handling or docking rails are frequently provided to facilitate the moving of airships out of and into the shed. These rails consist of metal-edged slots flush with the surface, running from inside of the shed well out on the field, and small trucks or trolleys are provided to run in the slots. When in use enough ballast is discharged to make the airship ride "light" and it is then tied down to the trolleys. As it is moved into or out of the shed the trolleys ride in the slots, holding the ship down and keeping it in a central position.

Wind Screens.

To reduce the danger of the airship striking the side of the shed when it is being moved in or out in the presence of a side wind, the British and French conducted extensive experiments with several forms of screens to break the force of the wind at the entrance. At first, solid fences were tried, one being built at each side of the entrance and radiating outward at an angle. It was found that these created eddy currents in the air and were of no practical value. Some experiments were then continued with open screens formed of slats or grill-work and those made of expanded metal screening proved the most helpful by considerably reducing the velocity of the cross wind at the entrance. There is much difference of opinion regarding the utility of even these latter types. It seems to have become accepted that airships cannot be moved in or out of sheds in the presence of strong cross winds. This is not so serious a disadvantage as it may appear, if the mooring system is to be used in operation of scheduled services and the shed only for overhauls and major repairs. Any shed station should have a mooring mast adjacent where an airship may be held if for any reason it is unable to enter the shed immediately.

Inflation Gas and other Supplies.

Both mooring masts and sheds should be piped for water, gasoline and inflation gas, the mast connections being provided at the top to suit the airships accommodated. The shed connections should be provided at several points and located so that the flexible pipes are as short as possible. Whether or not hydrogen generating or helium purifying plants are required will depend upon the operations. Usually one or the other of these will be required at airship sheds except-

Fig. 56.—Balloons preparing for James Gordon Bennett Trophy Race, 1928. (Photo, Kalec & Forster).

ing in special cases. In many cases where only mooring facilities are provided it will not be necessary to go to this expense, the inflation gas being received compressed in steel cylinders as the need arises. Suitable storage for considerable quantities of fuel will be required at any station.

Free Balloon Facilities.

The importance of free-ballooning for training, experiment, and as a sport, calls for particular notice here on account of its comparatively simple field requirements. Almost any fair-sized field can be adapted to the purpose, even the top of a large building has been used. Whereas hydrogen and helium are the only two gases satisfactory for airship use, any gas having a specific gravity of 0.1 to 0.5 (relative to air) is suitable for free balloons. Its only other requirements are sufficient quantity and reasonable cost. The best location for a free balloon station is usually near a supply of by-product hydrogen, such as is found in the manufacture of electrolytic oxygen, soda, washing and bleaching powders, etc. Coal gas, a constituent of ordinary city illuminating gas, is also very well adapted for balloon use.

CHAPTER XIII

AIRWAYS LIGHTING EQUIPMENT*

The Importance of Night Flying.

With the development of airways lighting, Kipling's "Night Mail" passed from the poetic into the steady grind of everyday business life. His visionary flying machine has been realized in prosaic airplanes shuttling back and forth over their routes guided largely by a chain of twinkling beacons on the ground below. Night flying is vitally important in air transport. It is one of the rules of the game decreed by force of circumstance. All other types of conveyance operate through the night and aviation would labor under a tremendous handicap were its uses confined to daylight hours. During the past several years great progress has been made and we have reached the point where flying by night can be made as safe as flying by day, while navigation becomes easier. The U. S. Department of Commerce, being fully alive to the necessity of night operation in civil aviation, has embarked upon a comprehensive program and has already lighted several thousand miles of airways. The Federal Government naturally cannot include the lighting of local airports as these questions are matters to be taken care of by those most directly interested. Hence the fullest consideration should be given to night flying equipment when a civil airport is planned. If the prospect of night operations does not justify elaborate equipment at first, at least the airport should be provided with some emergency equipment if only for the benefit of the pilot coming in just after dusk. Where

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* Prepared with the cooperation of: Wallace Kellett, Secretary-Treasurer, The B. B. T. Corporation of America; H. C. Ritchie, Aeronautical Specialist, General Electric Company; R. W. Cost, Transportation Lighting Engineer, Westinghouse Lamp Company; P. R. Bassett, Searchlight Department, Sperry Gyroscope Co.; A. V. Conover, Vice-President, Interflash Signal Corporation; L. M. Merrill, Manager of Marine and Aviation Division, American Gas Accumulator Company; Claude Neon Lights, Inc., and Crouse Hinds Company.

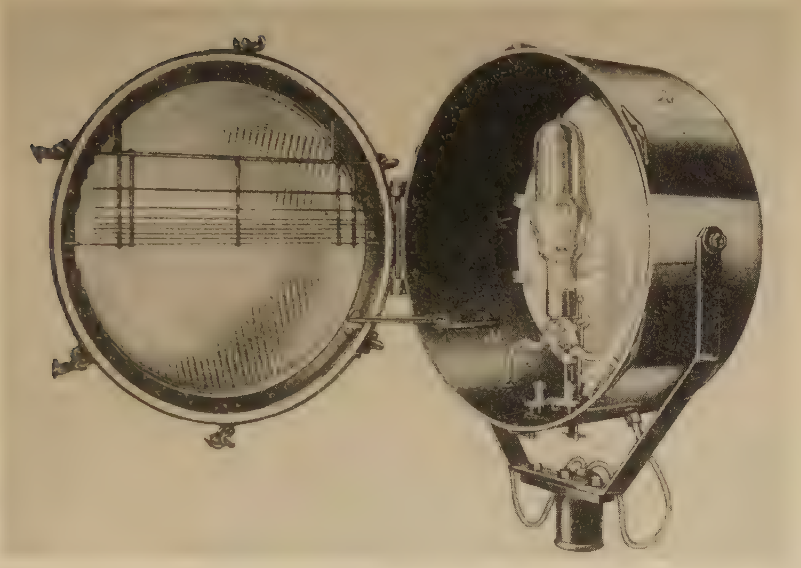

Fig. 57.—Crouse-Hinds 24-inch revolving beacon.

continued night flying is expected the airport should be adquately equipped. The cost of this varies greatly according to local needs, material and labor costs, etc., and may range from a makeshift at $2,000 up to $15,000, or more for a complete installation. In some cases it may run up to $30,000. However, an airport can usually be fairly well equipped for this purpose for about $5,000 to $7,500.

Night Flying a Question of Lighting.

The whole night flying problem is one of lighting; if all nights were brightly lighted, as by the full moon, there would be no problem. Flying by the light of the moon, without auxiliary equipment, has been extensively carried on. However, for regular flights night after night, proper lighting is essential if we are to remove the element of danger which accompanied our night flying during war times. The lighting problem resolves itself into five divisions: (1) taking off; (2) following the route; (3) avoiding collisions; (4) service

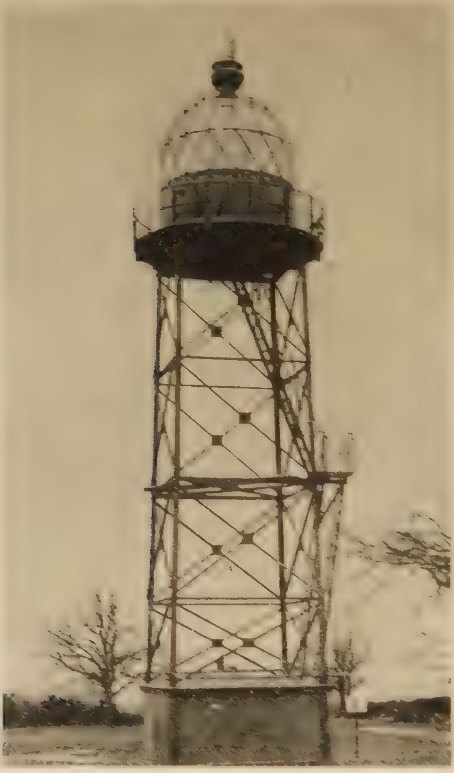

Fig. 58.—Airways beacon of the AGA Acetylene type installed a few years ago at Cranbrook, England, and which is revolved by pressure of the gas. Its illumination is controlled by means of the valve at the extreme top which operates when the sun sets in the evening.

landing; (5) emergency landing. (In this Chapter, lighting equipment will be discussed mainly with regard to landplane operation as the special requirements of seaplane bases and airship stations are taken up in the Chapters on these subjects). Of the five problems listed above, the last is by no means the least. Taking off presents no problem beyond that of avoiding collision with obstacles surrounding the airport. If these are marked by means of lights and if the pilot is familiar with the field, nothing more is necessary. Indeed, it is quite possible to take off in comparative safety without any lights if the pilot is familiar with the field. However, his sensations during the operation would be none too comfortable and engine failure at the critical moment might prove disastrous.

The Major Problems.

The question of following the route may be answered by use of either radio or light beacons or a combination of the two. Only the lights will be discussed here as the use of radio will be taken up separately in the Chapter on that subject. Both installations are desirable but the lights should be installed in any case as they may be followed by any aircraft without the use of special equipment. Where light beacons are installed along the route so that one is always in sight, flying in reasonably clear weather becomes a matter of following a chain of lights. Barring flights over mountainous districts, collisions with obstacles are avoided by flying at sufficient altitude to avoid them. In flying through mountainous districts, the beacon chain must be depended upon to indicate the airway through the mountains. Collisions with other aircraft may be avoided (excepting in fog) if each aircraft carries flying lights after the type called for in Department of Commerce Regulations. Decreased visibility impairs the efficiency of the beacon lights and dense fog makes them practically useless but here radio offers a promising means of solution. In either case the question of landing is perhaps the most serious problem. This question presents two problems in one: (1) that of effecting landings at regular airports and (2) that of finding a field and effecting a landing thereon in an emergency such as a case of engine failure. Extensive night flying experience in the past several years brought out some lesser problems but these have been largely solved and enough to make night flying thoroughly practical with proper equipment. One problem of this type was found in the necessity of reducing reflection of light by the revolving propeller, which tended to dazzle the pilot. It was found also necessary to remove glare of engine exhaust from his range of vision and to adjust the glass windows of closed cabin airplanes to decrease reflection of lights.

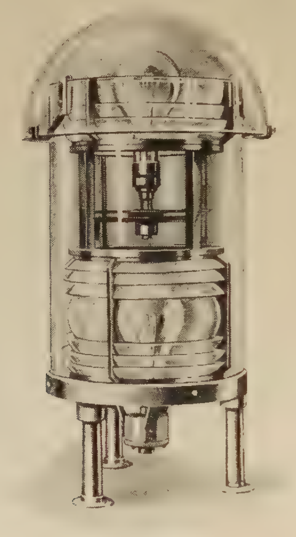

Fig 59.—B. B. T. airways beacon of flashing non-rotating type. Note the two sets of lenses.

Visibility of Beacons.

Considering the question of route beacons, these should be designed and located so that there is considerable "overlap" in their range of visibility. That is, if the beacons are normally visible for a distance of 25 miles they should be placed not more than 12 miles apart and preferably closer. Each beacon should be placed on a tower or otherwise raised sufficiently high to eliminate interference by surroundings or occasional ground fog. In this way the pilot will be able to sight his course, from time to time, by two or more of the beacons which are within range and the utility of the chain will be less impaired by slightly "thick" weather. So far as weather interference is concerned, the greater the power of the beacons and the closer they are spaced, the less this effect will be. However, there is more to be gained by use of closer spacings than by proportionate increase in the beacon power. The range of visibility of beacons and their spacing must be considered in conjunction with their cost and several other elements to which reference will be made. Beacon installations can be made also of value in following a route by day if bearing route numbers or some other means for identification from the air. Each beacon should have a distinctive characteristic so that it will be easily and clearly distinguished from all other beacons or lights along the airway or in the vicinity. This characteristic should also be of such a nature that each individual beacon will serve to give the pilot his exact position on the course.

Route Beacon Spacing.

The cost of beacon lights increases out of proportion to their range of visibility. Thus the most economic arrangement, as well as

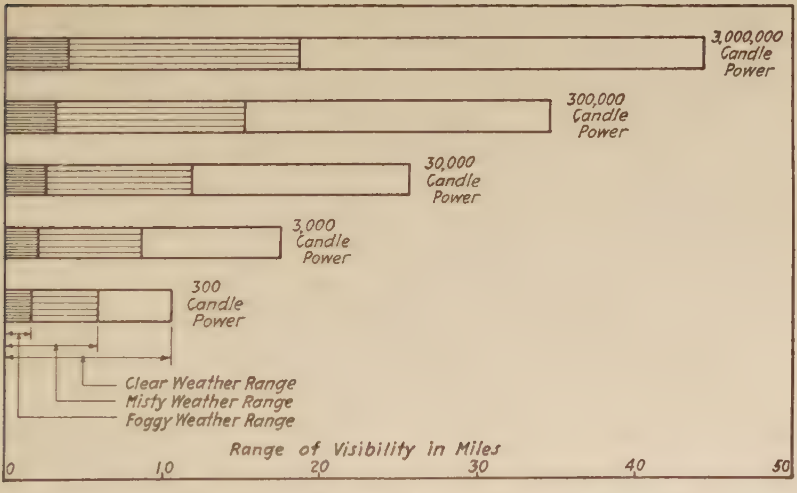

Fig. 60.—Range of visibility of beacons under varying weather conditions. (Courtesy of American Gas Accumulator Company.)

the requirement of visibility in "thick" weather, calls for beacons spaced reasonably close together. However, there is also a lower practical limit on the reduction of spacing through the difficulty of finding beacons of too small range and through the existence of a minimum initial cost and maintenance for individual beacons. Hence the most desirable spacing for any route will depend upon local conditions and will include such items as: type of beacon; installation costs; normal visibility on course; rigidity of schedule to be flown; interfering or confusing lights liable to affect beacon visibility; necessity of flying through mountain passes. Usually the spacing will range from 5 to 20 miles, while the normal visibility of the beacons will be from 2 to 4 times the spacing. A reasonably close spacing of moderate size beacons keeps the cost down, simplifies the work of the pilot in following the course and facilitates the problem of refinding the route in case of his losing it through misty weather. These notes apply only to chains of beacons for flying over land. Guides for use in over-water flying present totally different conditions and which compare somewhat with those of marine practice.

Types of Beacons.

The beacons themselves may be either of the electric incandescent lamp, acetylene, electric arc, neon tube or any other type, although the first two types have been used the most extensively up to date. Where located in isolated positions, it is essential that they be designed to operate for extended periods absolutely without attention. While the desirable period of non-attended operation depends upon local conditions, one month might be considered the minimum and six months as preferable. This requirement rules out the electric arc for general use along the airway, leaving the field to the incandescent electric and the acteylene types. This, of course, does not apply to installations at airports. Obviously the use of the electric beacon depends upon the availability of some thoroughly reliable source of power. The question of whether or not beacons should be allowed to remain burning throughout the 24 hours of day and night, is largely a matter of cost of operation. Where reliable attendance

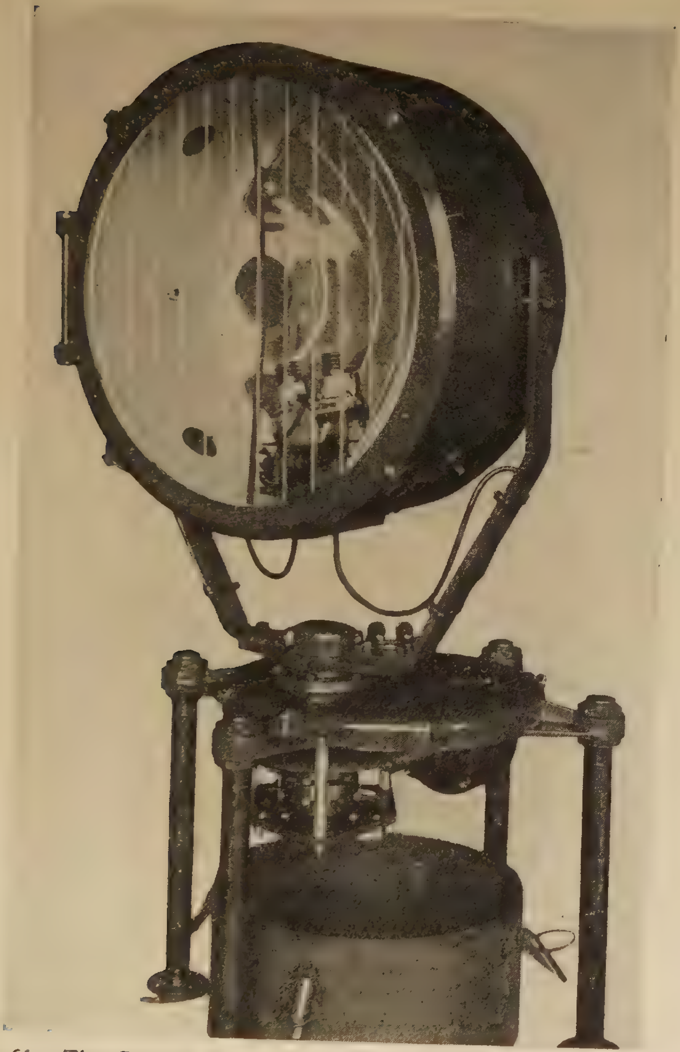

Fig. 61.—The General Electric Company's 24-inch rotating beacon.

is available, they might be kept lighted only at night. If an automatic device is provided to control the beacon, it should operate in accordance with the degree of natural light rather than with the time of day. Thus the beacon can be brought into use exactly when it is required instead of at some fixed time without regard to daily variations in light conditions. Automatic devices for controlling lights should be so designed that, in event of their becoming inoperative, the light will burn continuously.

Rotating and Flashing Lights.

Most beacons constructed to date have been of either the rotating or stationary flashing types, as flashing or moving lights can be detected and identified more readily than stationary continuous ones. They are also somewhat more economical in operation as the rotating type need only direct its beam in one direction at a time and the flashing type is lighted only part of the time. As a general rule, the larger beacons have been of the revolving type, while the smaller ones have been of the stationary flashing type. One recently developed type of rotating beacon is provided with a mechanism which causes it to pause in its rotation for the purpose of pointing its beam along the direction of the course. This is a distinctly important advance in airways beacon development. Indeed, it has been found so important to have the direction of the course indicated that development has been continued to the point where separate course beacons are sometimes provided in addition to the rotating ones.

Recent Department of Commerce Beacons.

Recent installations made by the U. S. Department of Commerce consist of three lights on each tower: (1) the rotating beacon, consisting of a 1000-watt lamp in a 24-inch reflector and (2) two course lights of from 12-inch to 18-inch in size, each using a 500-watt lamp. One of the course lights points in one direction along the course while the other points in the opposite direction along the course. As the rotating beacon revolves, it makes and breaks circuits feeding each of the course lights, flashing a code signal first in one direction and then in the other. Furthermore, an amber-colored beam has been adopted on these course lights to signify an emergency field in the vicinity of the beacon, and a red beam is used to indicate the absence of any emergency landing facilities in the vicinity of the beacon tower.

In the case of beacon installations at airports, it is always advisable to provide the airport with a beacon of long range, say 50 miles in clear weather, even in cases where the airway is lighted by means of beacons of lower power. This provision enables pilots who have lost the course, or who approach from other directions, to find the airport with less difficulty.

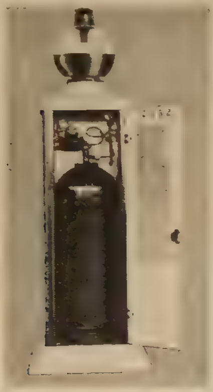

Fig. 62

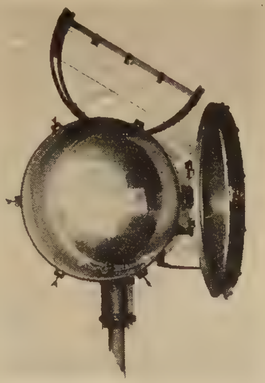

Fig. 63

Fig. 62 is an airport boundary marker light of the AGA make, with the housing opened to show the acetylene gas cylinder and pressure governing valves. Fig. 63 shows the Westinghouse 24-inch airport projector, a wide-angle type suitable for landing flood-lighting. The projector door is opened in this illustration to show the louvers used to cut off upward distribution of light and eliminate dazzle. In the photograph the louver frame is shown swung upwards to permit access to the interior of the projector.

Marine Beacons and Airway Beacons.

Beacons for aircraft guidance present at least one requirement which differs radically from the requirements of marine beacons and this is in the vertical range of visibility necessary. While marine beacons need only provide visibility near the surface of the water, the aircraft beacon should be visible from a considerable altitude. This altitude depends somewhat upon local conditions and may be also affected by future types of aircraft, however vertical visibility of 8,000 or 10,000 feet might be set down as desirable. Long range visibility at such heights is provided by the main beam; visibility at altitudes in the vicinity of the beacon may be obtained by the use of special lenses, stray light, or reflection of part of the main beam. In any case, it should be possible to detect the beacon even when flying at some height directly above it.

Equipment for Landings.

Several lighting systems have been used for effecting night landings at regular airports. In practical use, however, it was found necessary to illuminate a certain area of the landing surface so that the pilot could estimate his height above the ground just previous to

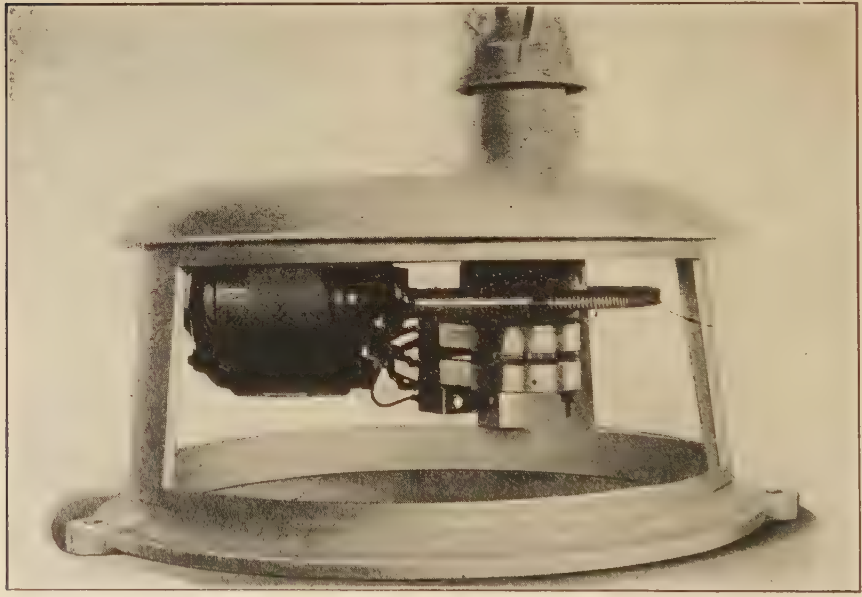

Fig. 64.—Revolving mechanism of the Sperry airways beacon, showing the motor drive and system of feeding through slip rings.

contact with it. One of the earliest methods, and which is still good for a temporary installation, is that of using a battery of portable floodlights to illuminate the landing area and the direction of run. At least four, and if possible six, floodlights should be used for this purpose. They may be self-contained units on wheels or may be ordinary floodlights mounted as a battery on a truck or trailer, the latter system being the better. Either acetylene or electric lights may be used for this purpose and, where the latter are used, the lights should be fed by a generator or storage battery carried on the truck or trailer. The system which has been most generally used and which represents the best practice is that of installing powerful stationary floodlight units capable of illuminating a substantial part of the landing area. This system necessitates the use of either one of the largest units at one side of the landing area or a number of those of intermediate size around it, as may be necessary to suit local conditions.

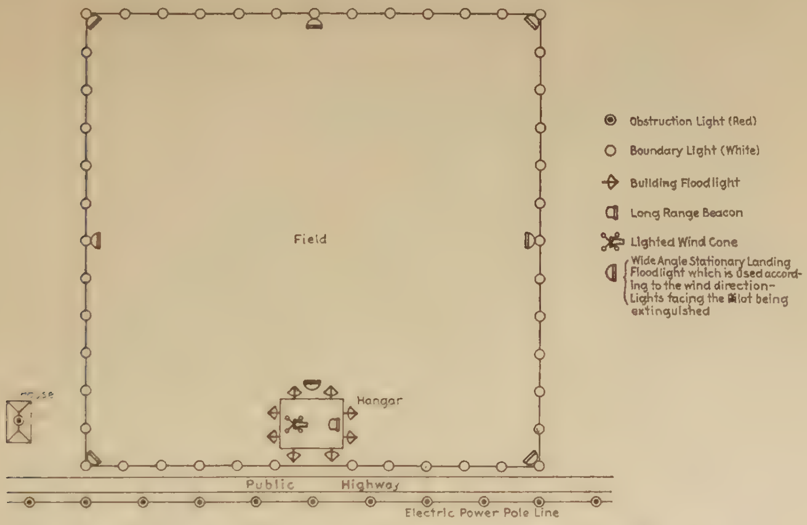

Fig. 65.—Diagram showing one plan of airport lighting for night flying. It must be noted that the arrangement, types, and number of lights, have each to be adapted to suit the local conditions; hence, this drawing shows merely a general scheme.

While more expensive to install, it is much more convenient to use than is the movable floodlight system. For a permanent installation no other system should be considered.

Use of Floodlights and Emergency Flares.

Floodlights for landing use should provide for landings from any direction and should never be mounted in high positions, such as on the roofs of buildings, where this can be avoided. When lights are so placed they often project a strong glare into the eyes of landing pilots. In cases where night landings are to be made only in emergencies and the cost of elaborate equipment is not justified, ordinary railroad track flares may be used. As these flares cost only a few dollars per dozen, a quantity should be kept on hand at every airport whether night landings are expected or not. When an airplane is nearly due, or when an unexpected machine signals its arrival by circling the field, four or more of the flares may be set on the ground and lighted in T formation, at the point where the pilot is expected to set the wheels down. The leg may be used to show the direction in which the landing should be made by rotating the T to represent the outline of a landing airplane. While the pilot should try to avoid hitting the burning flares, danger of fire is remote on account of their small size and the speed of the moving airplane. In other cases where an emergency night landing has to be made at an airport without floodlights, a makeshift lighting system can be obtained by parking two or three automobiles so that their headlights point into the wind and illuminate the field about the part where the landing is to be made.

Marking of Obstacles.

All dangerous obstacles around airports and intermediate fields should be rendered visible to avoid collisions when night landings are made. This applies particularly to such obstructions as radio masts, telegraph poles, wires and other obstructions which are of low visibility even when the night is not dark. Marking may be accomplished by either illuminating the obstacles with projected light or by

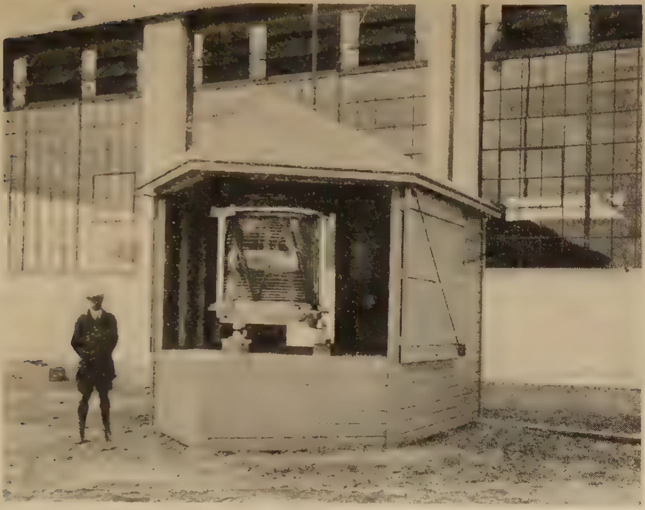

Fig. 66.—The 500,000,000-candlepower B. B. T., airport floodlight installed at Toledo, Ohio, Airport. (Photo, L. W. Platt, Toledo, O.)

marking their outlines or extreme points with small lights. The flood lighting method is usually much to be preferred as it shows the buildings or obstacles as they appear to the pilot in daylight. No matter which method is used, care must be taken to so arrange all lights that risk of dazzling the incoming pilot is reduced to a minimum. Thus, if floodlights are used to illuminate buildings or other structures, it will be obvious that they must not point upwards at a large angle. Likewise, where outline or extreme points are marked, the lights used must be of low power and low illuminating intensity. Frosted or opalescent globes or the principle of reflected light may be used also to decrease glare.

Boundary Lights and Wind Indicators.

It is necessary to also provide lights marking the boundaries of the field. At airports these lights may be of any type, electric, kerosene, acetylene, gasoline, etc., as happens to be the most convenient. At intermediate fields, where attendants are not available for maintenance of lights, they must be of some type capable of operating for extended periods without attention just as in the case of some route beacons. In all cases boundary lights should be placed relatively low, about 2 to 4 feet from the ground usually being satisfactory, and they should be visible from any point of the compass from which the field can be approached by air. If the boundary lights are to be electric and operated on a series circuit, the transformer and circuit should be arranged to avoid the necessity of carrying voltages of more than 250 up to the light. Although boundary lights are spaced about 200 feet apart, this distance should be modified where necessary to prevent danger of their being confused with other lights in the vicinity. Department of Commerce Regulations fix 300 feet as the *maximum* spacing.

Color of Lights, etc.

The use of white lights for boundary marking has been adopted by the Department of Commerce as standard practice for the United States but red lights are generally used in other countries. Green lights are used to indicate the best landing directions where the approaches are poor in other directions. While boundary lights have, in the past, been of either the continuous burning or flashing types, the former is preferable as this makes the field outline constantly visible. Consequently the continuous type has been adopted by the Department of Commerce. Where considerable flying is to be done, the boundary lights might be increased in power to provide illumination for landings *in addition* to the floodlights already referred to. Some type of illuminated automatic wind indicating device is another necessity of night flying equipment. This may consist merely of an ordinary wind cone lighted internally or from above by means of a floodlight or cluster of lights. Although the *indication* of the device will not be evident from that distance, it is desirable that the wind indicator be capable of being *identified* from a distance of about 3,000 feet in clear weather.

Ceiling Projectors.

The ceiling projector becomes an essential addition to the airport lighting equipment if extensive night flying is to be done. This consists of a projector which is directed into the sky at an angle and is used to determine the height of the lowest clouds at night. The Department of Commerce Regulations require use of a 12 or 14-inch

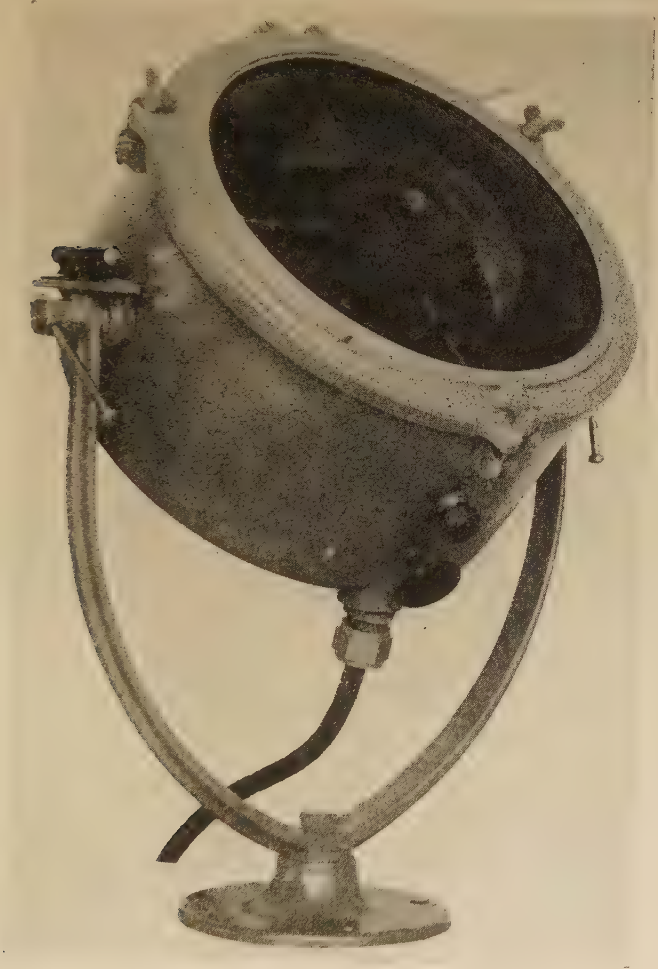

Fig. 67.—Ceiling projector, showing use of spirit level.

searchlight with a 250 or 500-watt incandescent bulb for this purpose. Some means for measuring the angle of the projector is also necessary and this is used in conjunction with a separate inclinometer or other such arrangement calibrated to read directly the height of the clouds.

Emergency Landings.

The foregoing descriptions cover the means for finding the route, finding the fields, marking their limits, showing wind direction and for effecting landings at regular airports. However, for effecting landings at intermediate fields either wing tip cartridge flares or wing tip searchlights must be provided on the airplane itself. The flares were formerly used for this purpose but the searchlights have since come into general use for civil purposes because of their convenience and the elimination of the fire hazard which accompanied use of flares. Another important item of night flying equipment is the parachute flare. This device consists of a high power cartridge flare, carried by a parachute which opens when the device is released. When the pilot, looking for a landing field, wishes to view the ground below, he releases this flare to provide illumination. The use of parachute flares in civil operations must be avoided excepting in emergencies because of the danger of their starting fires if they reach the ground before burning out.

Landing in Fog.

Finding the airport and effecting a landing in the presence of fog still remains a serious problem but we seem to be nearing its solution. This question is being attacked by use of both radio and lights. The radio development will be taken up briefly in the Chapter on that subject but it seems fitting to say a few words here regarding progress in lighting as applied to this purpose. The manufacturers of neon tubes have been cooperating with the British Air Ministry and the U. S. Air Mail Service and operators in experimenting with the application of these to landings in fog. The neon tube, it might be explained, is a system of electric lighting utilizing a tube from which the air has been exhausted and which is filled with the rare gas neon. As an electric current is passed through the tube it emits a soft glow of orange-red hue. Arrangements of these tubes have been laid on the field surface and it has been noted that the distinctive color of this light possessed unusual value for identification in fog. However, this whole question of fog landings is still in the experimental stages and the equipment need not be considered as applicable to most civil airports just yet. Perhaps the fog may finally be conquered by a combination of distinctive-color lights and directive radio. Perhaps the present experiments on fog-dissipation may point the way to another solution, but it is yet too early to count much upon this possibility.

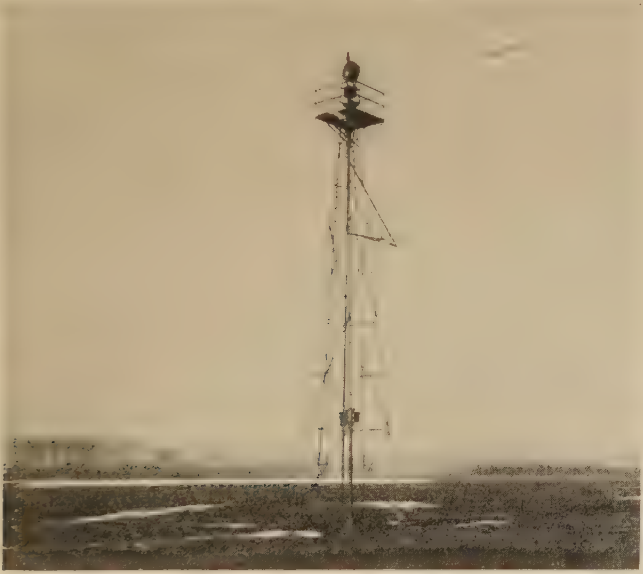

Fig. 68.—Ideco 51-foot beacon tower at Schenectady, N. Y., Airport. The arm extending out from the tower on the far side is used to carry a wind cone although the cone was not in place when this photograph was taken.

CHAPTER XIV

RADIO EQUIPMENT FOR AIRWAYS*

By MALCOLM P. HANSON, *Radio Engineer,*
Byrd Antarctic Expedition

Applications of Radio in Air Commerce.

Radio promises to become of increasing value with the development of commercial aeronautics. It offers not only a means of facilitating navigation of aircraft but it also increases the safety and convenience of airline operation. In airline operation it has recently been introduced here and has been used abroad as a matter of routine for several years. The passenger airplanes of the British Imperial Airways are equipped with radio telephone transmitting and receiving sets and report their position to the Croydon operator periodically while over British territory. Ground direction finders are also located at Lympne and Pulham and any airplane asking for a bearing or position by radio can obtain this information on short notice. The French are similarly employing radio equipment extensively in commercial aviation and the general tendency abroad is to encourage or require both radio transmitters and receivers on all large passenger transport airplanes. A radio weather service has now been established on the air mail route between New York and Cleveland so that weather reports can be transmitted direct to pilots en route.

Developments in the United States.

Radio equipment on aircraft is obviously of value only to the extent that there exists equipment on the ground to serve it or to connect with it. In addition to the service on the New York-Cleveland route there are at the present time numerous radio stations along our coasts, and around the Great lakes, which maintain constant watch for marine traffic and which are in position to handle telegraphic messages with aircraft on wave lengths of 600 meters and above. Many coast stations and Army and Navy stations broadcast weather reports and other information on definite schedules by radio telegraph. Many Naval stations broadcast regularly telegraphic bulletins for flyers giving weather forecasts and conditions in detail and including weather reports from various Naval aviation stations. The Navy also operates a number of direction-finding radio stations along our coasts, which are now calibrated in all directions, inland as well as toward the sea. By means of these, directional bearings may be furnished by radio to any aircraft as well as to marine vessels requesting such. This service is operated on a frequency of 375 kilocycles (800 meters). Many telephonic broadcasting stations throughout the country include regular weather reports in their programs and this service will undoubtedly be extended for the special benefit of flyers as the need grows.

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* Prepared with the cooperation of: Dr. J. H. Dellinger, Chief of Radio Laboratory, Bureau of Standards and S. W. Goulden, Commercial Engineer, Radio Corporation of America.

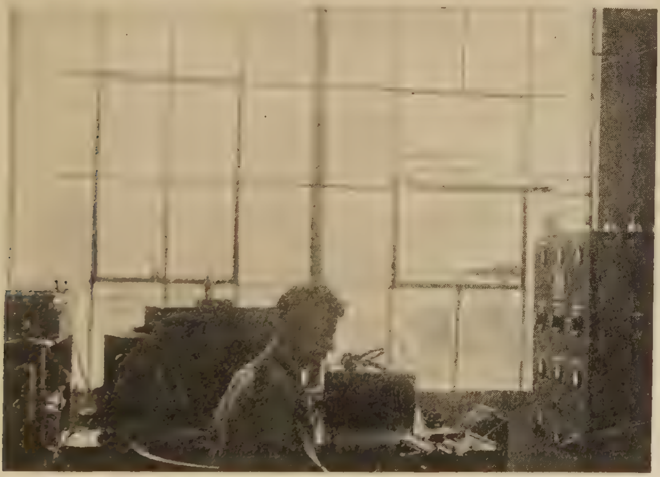

Fig. 69.—Airway radio station at the Toledo, O., Airport.

Department of Commerce and other Activities.

The Department of Commerce has embarked upon a program of equipping airways with radio beacons and radio telephone and telegraph stations and this should give great incentive to the equipment of aircraft and airports with radio facilities. Installations may vary from simple receiving sets up to complete equipment for two-way communication over several hundred miles. Receivers may be installed at first and, as the use of the service expands or the need arises, transmitting equipment may be added later. Apparatus has been developed by the U. S. Bureau of Standards for attachment to a simple receiving set, to show the pilot his relation to the course by means of an instrument on the aircraft actuated by radio signals from a directive beacon. Former equipment necessitated the use of earphones and audible signals for this purpose.

Uses of Radio in Airways.

Radio equipment is of value in airways operation for assistance in navigation, communication between aircraft or between aircraft and the ground, communication between airports, and other uses. Radio devices on aircraft in combination with suitable equipment on the ground make it possible for the flyer to determine both his direction with respect to his destination and also his geographical position. Experiments are being conducted with other devices to indicate to aircraft the location of a landing field in fog and to indicate the altitude of the aircraft above the surface of the ground. Communication with aircraft in flight is of value for transmitting weather information, for despatching and routing, calling for aid in emergencies, and communication for the convenience of passengers. Already it is technically possible to provide communication between occupants of the aircraft in flight and any telephone subscriber and this service could be established if demand arose in the future. Ground radio stations are of value for the exchange of weather information with aircraft or with other stations, for despatching and tracing movements of aircraft, for exchanging messages with aircraft and for handling the miscellaneous business messages between a chain of airports.

Types of Equipment.

Including both the types of apparatus which have already been reduced to a practical basis and also those which are still in the experimental stages, airways radio equipment might be classified as: (1) *directive beacons*, for pointing out air lanes or relative directions to aircraft equipped with ordinary radio receiving apparatus; (2) *marker beacons*, at intervals along the airways which enable aircraft to ascertain their distance along the course; (3) *airport radio telephone stations*, for communication with aircraft in flight and with other airports in emergencies, for broadcasting weather information and miscellaneous other uses; (4) *direction finding stations*, for determining direction for any aircraft equipped with radio transmitter and (by cross-bearings from two or more ground direction-finding stations) determining the aircraft's position upon request,—the airport radio station being adapted to serve this purpose as well as its other uses; (5) *landing field locating devices*, for marking the exact location of the landing field by radio when low visibility hides the field.

Directive and Marker Beacons.

The directive beacon, while emitting radio waves in all directions, makes it possible for aircraft equipped only with a radio receiving set to maintain its course toward or away from the beacon within an accuracy of a few degrees. The aural system, now in use and described here, will probably be superseded by the visual type of indication. When on the course to which the beacon is set, the listener aboard the aircraft hears the regular beacon signals as long-drawn-out but even dashes. Upon diverging to one side or the other the dash becomes uneven and within a few degrees from the set course becomes discernable as a Morse "A" or "N" instead, depending upon whether the divergence is to the left or right. Radio frequencies around 290 kilocycles (1034 meteres) are used for this beacon transmission and the usual dependable carrying range is between 100 and 200 miles, depending upon power used and sensitivity of the aircraft receiver. The directive beacon gives no indication of the distance

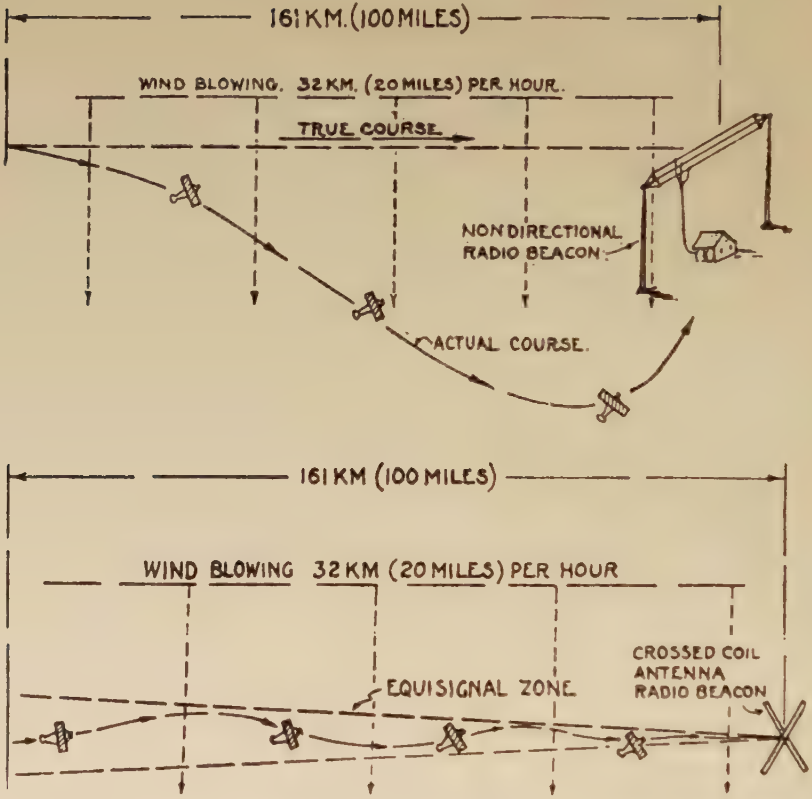
161 KM.(100 MILES)
WIND BLOWING. 32 KM. (20 MILES) PER HOUR.
TRUE COURSE
NON DIRECTIONAL RADIO BEACON
ACTUAL COURSE.
161 KM (100 MILES)
WIND BLOWING 32 KM (20 MILES) PER HOUR
EQUISIGNAL ZONE
CROSSED COIL ANTENNA RADIO BEACON

Fig. 70.—Diagrams prepared by Dr. J. H. Dellinger to illustrate the effect of wind drift in air navigation when using the radio direction finder (upper drawing) as compared with the directive beacon (lower drawing).

traveled, hence it is desirable to install marker beacons at points about 25 miles apart along the course. The marker beacon consists of a non-directive and low-power radio transmitter emitting a characteristic signal which is detected and identified by the pilot as he passes near the locality,—the relative strength of the signal enabling him to estimate his distance from this beacon. A chain of marker beacons thus serves the purpose of "milestones" to keep him informed of his progress along the course although he must depend upon the directive beacon to keep him on this course.

Directive Beacon Equipment.

The directive radio beacons in use today employ a central mast or tower about 70 feet in height and from which the antenna wires are strung in four directions, 90 degrees apart, to small poles about 10 feet high and some 150 feet from the central mast. From this point they return to the beacon transmitter at the base of the mast, being strung about 8 or 10 feet from the ground to allow clearance for pedestrians and vehicles. The actual ground occupied is thus a square plot with diagonals of 300 feet. To avoid errors in calibration, this plot should preferably be level and uniform ground several hundred feet or more from any buildings, overhead electric wires, or other metallic structures. Since it is obviously undesirable to obstruct a small landing field by placing such equipment directly at its side, it is usually located a reasonable distance away but yet kept close enough to guide the incoming pilot to the airport in thick weather. If a radio receiving station is used at the airport, the radio beacon should be kept several thousand feet away from it to avoid interference with routine reception. This type of beacon has been operated very successfully in the United States by the Bureau of Standards, the Army Air Service and commercially by the Stout Air Services, Inc.

Airport Radio Communication Stations.

Depending upon the purpose and class of communication desired, as well as upon the funds available, ground radio transmitters in airways use will vary in power from about 50 watts in the antenna up to 1,000 watts or more. The corresponding cost for complete installations will vary upward from around $1,000 for a simple installation to many times that sum for the more elaborate ones. Manufacturers have equipment of standard design already developed for marine coastal, or broadcasting use, which can easily be adapted to the special requirements of airways and the particular needs of the individual airport. Transmitting frequencies for aircraft have been allocated by the Federal Radio Commission. For general utility, transmitters may be arranged to employ at will telephone and both continuous-wave or modulated-continuous-wave telegraphy. Airport radio stations should be easily accessible from the airport office or should be connected therewith by a private telephone line.

Remote Control Radio Stations.

As pointed out elsewhere in this volume, location of the transmitting station on the field itself is undesirable on account of the flying hazard due to its antenna structure. By far the most satisfactory arrangement is the remote control radio installation as used at several American and European airports. Here the transmitter is located away from the flying field itself and 1,000 feet or more from the receiving station,—which may be located right in the main office building. A small low antenna suffices for the sensitive receiving equipment used and at which an operator maintains regular watch. The radio operator controls electrically the remotely located transmitter, which he can start and stop (without requiring an attendant at the apparatus except for periodic maintenance or repairs). A change from radio telephone to either continuous-wave or modulated-continuous-wave telegraphy, and if necessary a shift to different operating frequencies, may also be effected by remote control. A further and important advantage of the remote control station is gained through the receiving set being continuously operative even during transmission.

Airport Radio Station Facilities.

All airport radio stations should have land telephone connection and where the message traffic is heavy they should also have a direct connection with the local land telegraph station. Charging facilities must be provided for the batteries of the radio receivers, including both those of the ground station and of any aircraft which may be serviced. It may be desirable to have sleeping accommodations for at least one radio operator if circumstances require night watches.

All-purpose receiving apparatus at the ground station should preferably cover frequencies from 113 to 4,000 kilocycles (2650 to 75 meters). Separate receivers may be maintained to guard the different wave bands required. If there is considerable air traffic outside the radio operating room or if aircraft engines are frequently run nearby, it may be necessary to sound-proof the room by lining the walls with heavy felt or other sound-absorbent material. Since the running of aircraft engines within a few hundred feet of the receiving station or antenna may also introduce electrical disturbances in reception, it is best to locate the receiving room and equipment sufficiently away from such possible disturbances.

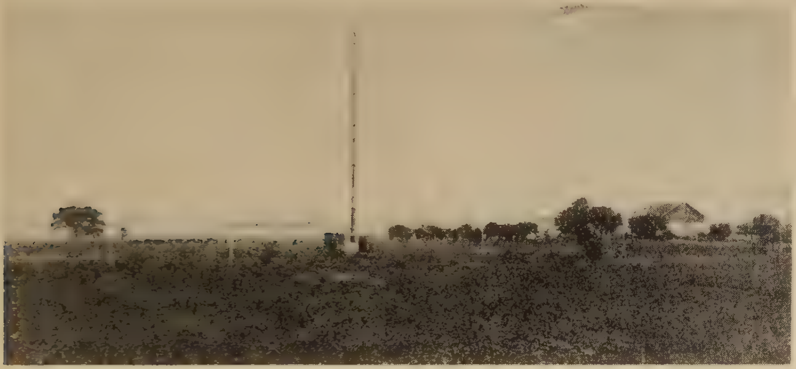

Fig. 71.—Antenna for radio beacon at Wilbur Wright Field near Dayton, O. (U. S. Air Service official photo).

Transmitting Generator Housing.

The floor space required for the ground transmitter depends upon its power and other requirements but it is relatively small. However, it should be borne in mind that most transmitters for radio stations require a separate power generating unit, consisting of either a motor-generator or rectifier and filter unit, to transform the available electric supply to smooth direct current of high voltage such as is required for radio telephony. Most sets will, in addition, be provided with a separate control panel for the power supply. Where a motor-generator is used it should be placed so that the sound of its operation will not interfere with radio reception. This means that it should be mounted in a separate small room or in a sound-proof box unless the transmitter is remotely controlled,—in which case all apparatus may be compactly installed in a small room or building.

Airport Station Antenna and Grounds.

Antenna requirements for ground transmitters vary with the wave length and, to some extent, with the power used and the permanancy of installation desired. For efficient communication on 550 meters an antenna system 100 feet or more in height is desirable and should be suspended between two masts or towers spaced about 200 feet apart. The antenna may be of either the conventional flat top or the cage type, preferably of T-shape with the lead-down portion in the center between the masts. The two antenna supports may be wire-guyed wood or steel masts or may be self-supporting towers of wood or steel lattice construction. The self-supporting steel towers with permanent steel cross members for supporting the flat antenna, as used at many broadcasting stations, are the most permanent type. For operation on the shorter waves, around 2300 kilocycles (130 meters), a considerably smaller antenna system is preferable. Since height is still desirable for greatest efficiency, a single mast or tower about 80 feet high may be used and the antenna suspended in slanting arrangement from the top. Where the larger antenna is also required, one of its suports will generally serve to elevate the smaller aerial at the same time. An efficient transmitter must also be provided with adequate ground connection, or with a counterpoise consisting of a network of wires suspended underneath the antenna at sufficient height to allow persons and vehicles to pass under it. Whether a ground or counterpoise connection should be used will depend upon local conditions. In general, a counterpoise is preferable to an uncertain radio ground connection.

Telephone and Telegraph Systems.

Radio communication with aircraft may take the form of either telephony or telegraphy and which of these is the more desirable will depend largely upon the individual circumstances. Radio telephony has the advantage that it does not require an expert operator on board the aircraft, but against this it has the disadvantage of requiring somewhat more bulky, heavier and more expensive apparatus. It has considerably shorter range for a given power, more chance of misunderstanding or error as compared to radio telegraphy, and is more susceptible to interference by radio communication, static or engine ignition systems as well as causing in itself more interference with other communication. It is probable that radio telephony will be employed for the smaller airplanes and for relatively short distance communication, while both radio telegraphy and telephone will be employed for airships and the larger airplanes which can carry an operator or mechanic qualified in telegraphy. For flexibility in operation it is customary to provide aircraft radio telephone transmitters with a simple switching device which changes the set to radio telegraphy, with a resulting great increase in range of communication. Similarly, most receiving sets provide for reception of telegraphy as well as telephony.

Radio Landing Devices.

Landing altimeters, employing radio or other electrical principles for indicating (in a fog) the actual height of the aircraft above the ground or obstructions, are being experimented with. These have the great advantage that, if successfully developed, they would indicate the actual distance entirely regardless of barometric pressure, visibility, or distance above sea level. While still in the experimental stages, several principles have been tried and some have shown considerable promise. To be really practical in use the apparatus must be developed to the stage where it will accurately and dependably indicate altitude up to at least a few hundred feet. Another problem which is engaging attention in many countries is the development of a suitable device to indicate to the incoming pilot the exact position

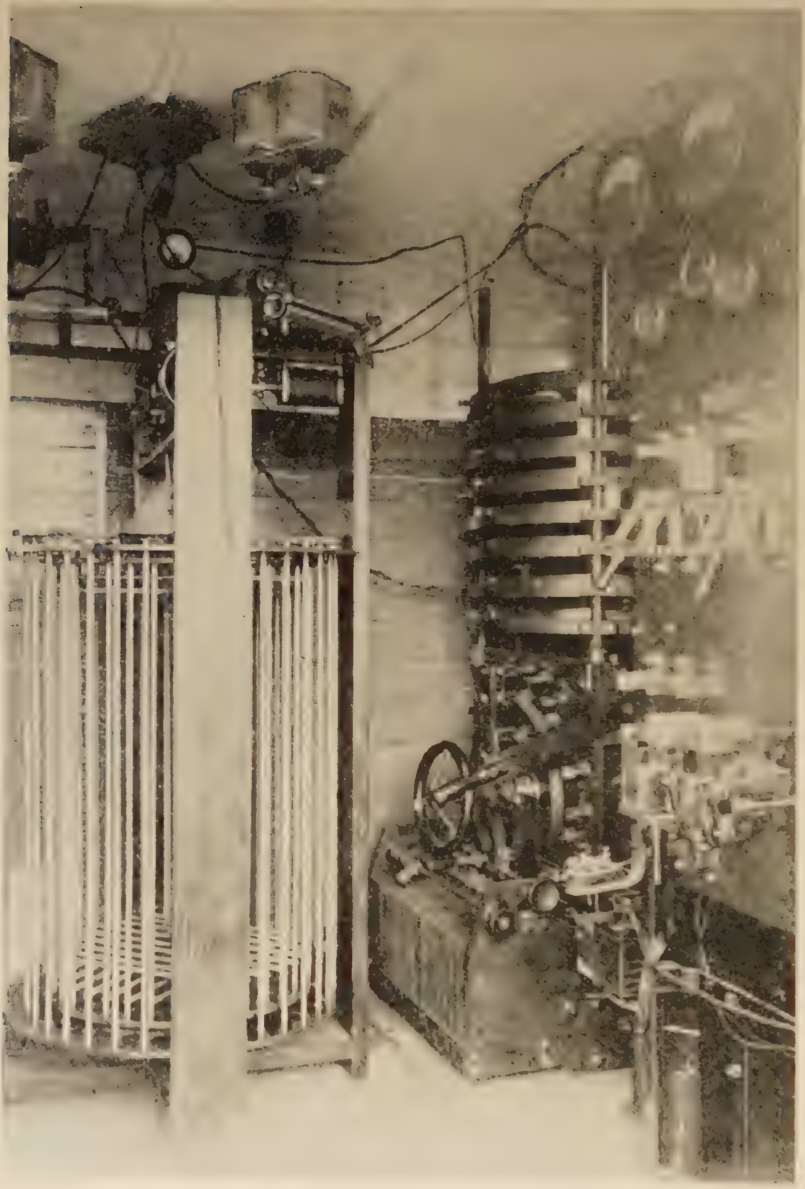

Fig. 72.—Operating equipment for radio beacon at Wilbur Wright Field near Dayton, O. (U. S. Air Service official photo).

of the landing field when hidden by fog. The experiments have included such methods as the use of a "leader cable" carrying low frequency alternating current and which led into the airport. The flyer is provided with electrical detection equipment which enables him to "find" this cable (or in other cases a "localizer" radio beacon) in a fog and to gauge his position from the intensity of the sounds received by his set. While very promising, these field locating methods are still in the experimental stages but they may become of practical value in the near future.

United States Radio Laws.

Radio communication in the United States is regulated by legislation enforced by the Federal Radio Commission and the Department of Commerce and to which regulations incidental reference has already been made. Only certain specified frequencies or wave lengths may be used for each class of radio communication, and government licenses are required for all transmitting stations as well as for the radio operators attending them. The license granted each transmitting station further assigns to it the distinguishing call letters.

CHAPTER XV

AIRWAYS METEOROLOGY*

The Influence of Weather.

When Mark Twain said: "Everybody talks about the weather, but nobody does anything," he did not anticipate airways development. For here we *must* do something, as may have been gathered from passing comments in the previous pages. The general direction of an air route is largely fixed by location of the cities which are to be served, but the actual course between these points is subject to some variation to suit flying conditions. This is somewhat on a parallel with the conditions found in other means of transport. In fact, routes of these other means are affected to a greater extent although usually by causes other than weather. Hence aircraft almost invariably come nearest to operation along a perfectly straight line. In the primary selection of routes it may be found necessary to depart from this desirable straight line because of ranges of high mountains through which the pilot must fly, the absence of adequate intermediate landing fields, or other such causes. In the case of airship operation over a long route, it may become desirable to modify the course from day to day to avoid unfavorable winds or take advantage of others. Hence the airway should be considered as a relatively wide strip rather than a straight line of no width.

Factors Affecting Airways.

The more important meteorological factors influencing choice of airways and airports might be listed as:

1. Fog, haze and smoke. (Frequency, depth and horizontal visibility).

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* Prepared with the cooperation of Dr. Jas. H. Kimball, Meteorologist, United States Weather Bureau, New York, N. Y.

2. Clouds. (Frequency and height in terms of visibility ceiling).
3. Wind. (Direction, velocity and altitude).
4. Precipitation of rain and snow. (Normal and extreme).
5. Storms. (Frequency, type, duration and severity).
6. Temperature. (Normal and extreme.)
7. Other factors such as humidity, pressure, etc.

In this listing the factors have been arranged in something approaching their order of importance to the aircraft operator, but it must be emphasized that such order applies only to the average case of airways and airport selection. In special cases the relative importance of one factor may increase while that of another may decrease. However, it is *always* important that the airway and airport be as nearly as possible free from fog, haze and smoke. It is almost equally important that the records show both airport and intermediate field sites to be reasonably clear of frequent occurrence of ground fog. Perhaps it may be well to explain here that meteorologists define "fog" as a cloud resting on the earth's surface and consisting of moisture which has condensed upon minute particles of dust, while they term "haze" any atmospheric density created by the presence of dust, smoke or causes *other than moisture*. Actually there are two types of fog: (1) the shallow, ground fog, mentioned above, which rises from the ground and which hides the surface from vision of the landing pilot; (2) the deep fog which forms over large areas of water and drifts inland, interfering not merely with landing but also with navigation. In addition to data on frequency, information on both the horizontal visibility and vertical depth of fog and haze is desirable. Although these are not available from the Weather Bureau printed reports, a record is kept of horizontal visibility and this can be obtained upon consultation with the local officials. Fogs and haze being frequently quite local in occurence, it may be found possible to improve conditions by moving to a site only a few miles away. This is a point on which the local Weather Office or some experienced meteorologist can be of help.

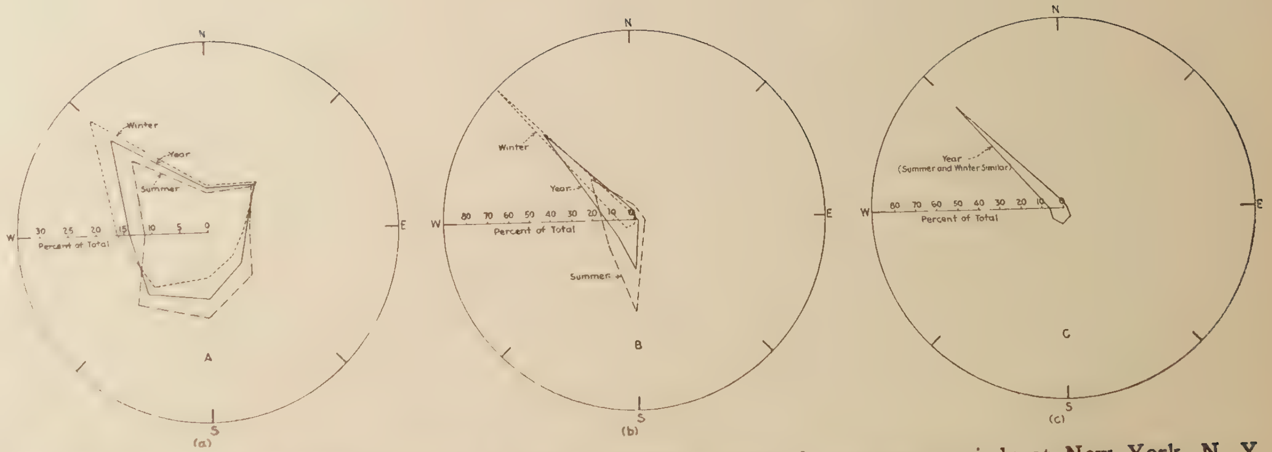

Fig. 73.—Frequency of various directions of wind in percent of total for ten-year periods at **New York, N. Y.** (a) all wind readings, (b) prevailing winds, monthly, (c) five-minute monthly maxium readings.

Effect of Clouds.

Clouds will offer less choice than fog or haze as the clouds are not greatly influenced by local conditions. In considering clouds their importance lies not in the frequency of all clouds but only in the frequency of clouds which are sufficiently low to interfere with flying. From the aeronautical point of view the governing condition is what is termed "ceiling,"—that is the vertical distance from the ground to the lowest clouds. This is the measure of clear vision for flying. As a general rule, cross-country flying in civil operations takes place at altitudes ranging from about 2,000 to about 5,000 feet. It is therefore desirable to have good visibility conditions in this area for the maximum number of days per year. In cases where the territory flown over is itself located at some height above sea level, these figures would have to be increased as they refer to flying over ground located within a reasonable distance of sea level. Thus, for *most* cases, the frequency of clouds above 5,000 to perhaps 8,000 feet is of minor importance as they will not hinder operations. Record of visibility ceiling has been kept at aerological stations in the United States for the past few years and is available to those having need of it. Where such information is not available the local meteorologist can often furnish valuable help even in the absence of official records.

Wind Direction.

Wind direction and velocity are of importance in two ways: first, in the arrangement of the airport take-off and landing areas so that the airplane or airship may take off and land into the wind the greater part of the time; second, in locating the airway so that conditions are generally favorable for operation. The first concerns only the ground speed and direction of the wind at the site and the air conditions of the "approaches" thereto. The second concerns the wind speed and direction at altitudes varying from about 2,000 feet to possibly 8,000 feet. Much of this information will be directly available from the Weather Bureau reports. In applying wind direction and velocity data to the placing of runways several studies should be made to determine the relative utility of various runway directions. Figure 73

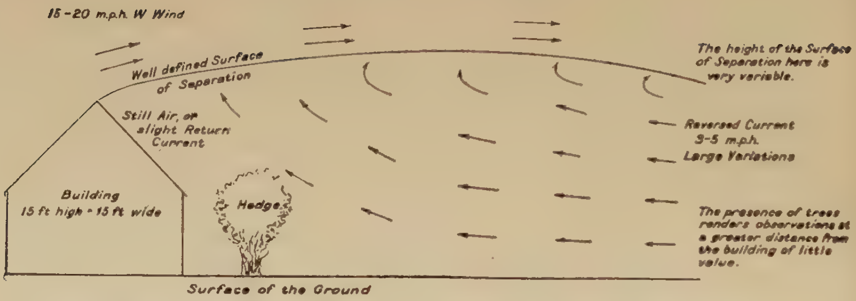
15-20 m.p.h. W Wind
Well defined Surface of Separation
Still Air, or slight Return Current
Building 15 ft high × 15 ft wide
Hedge
Surface of the Ground
The height of the Surface of Separation here is very variable.
Reversed Current 3-5 m.p.h.
Large Variations
The presence of trees renders observations at a greater distance from the building of little value.

Fig. 74.—Diagram showing result of a study of a treacherous air condition found in the vicinity of a British flying field several years ago.

shows some wind direction frequency studies for New York City, based upon the records of ten-year periods. In Figure 73-a there has been considered only the frequency of direction as recorded hourly and without regard to speed. This has been plotted for winter and summer seasons as well as for the year and the marked distinction between the seasons serves to illustrate the importance of specially surveying the period of probable operations. If the airport is to be used only in summer or if it is to be used only at certain hours of the day, a different arrangement may be required from that desirable for constant use.

Arrangement of Take-off and Landing Areas.

This first plot has the disadvantage of including records of low velocity winds, while we are not greatly interested in those of less than 8 or 10 miles per hour. Hence two other studies have been made in which the higher velocity winds were considered. The second plot, Figure 73-b is based upon the direction of the *prevailing* winds only, —thus giving some recognition to velocity,—and it clearly illustrates the importance of this point. To further study the effect of separating out the higher velocity winds, Figure 73-c has been plotted considering only the maximums, for each month, of 5-minute-average velocity readings. The gradual transition in form of the graph from Figure 73-a to Figure 73-c is most illuminating. It shows that landing and take-off will be made from every point of the compass at one time or other, but that the take-off and landing area desirability for all-year use ranges as follows: Essential: NW-SE area; Desirable: N-S and SW-NE areas. Where one area only can be provided (making what is known as a "two-way" field, as landings can be made from two directions only) it must be placed about NW-SE. Where two are to be provided, as is very desirable in this case and in most others, the second one should lie between N-S and NE-SW, preferably close to the former. It should, of course, be understood that even the two areas would necessitate frequent taking off and landing either at a moderate angle to the wind or without being able to make full use of the take-off and landing area. As this would become inconvenient only when combined with soft soil underfoot, it will not seriously affect the use of the airport. It might be noted here that the information on direction has been used as recorded

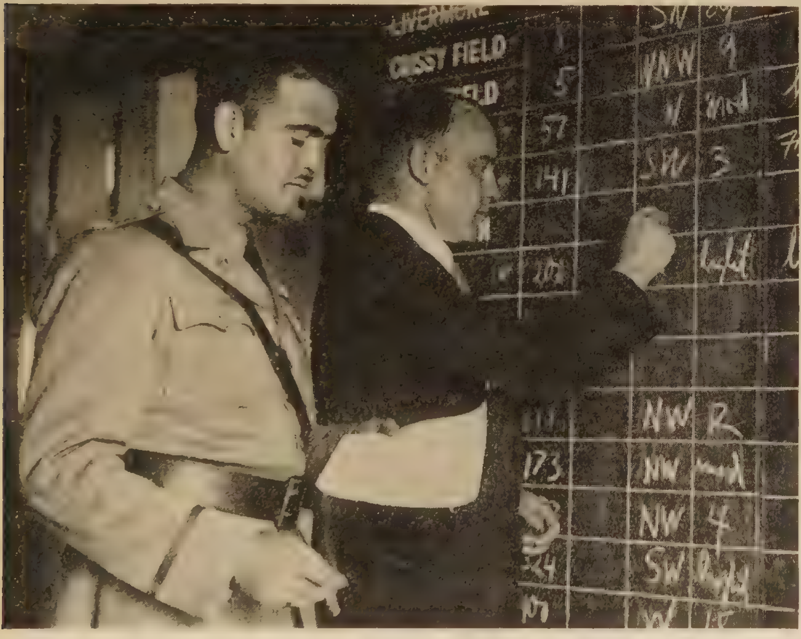

Fig. 75.—Recording weather data on the board at Oakland, Calif., Municipal Airport.

and that some direction corrections might have to be made for an actual airport site. In cases where wind direction varies greatly and choice of runway arrangement is, at the same time, limited, it is well to consider that the importance of winds to aircraft operation varies with the square of their velocity and directly as their frequency.

Rain, Snow and Temperature.

Rain affects the selection of an airport site only through the fact that it softens the soil and may cause trouble in cases where field drainage is not good. Consequently, small recorded rainfalls are of little or no consequence and only heavy, concentrated, precipitation need be considered. While the difference in rainfall will be too small to influence in itself the choice of sites, this factor may become of importance in connection with the drainage problem. Where rainfall is heavy, the field drainage will become of greater importance. Snow is of interest for the same reason as when melting, it causes even more trouble than heavy rains. However, snow becomes of interest also for its effect upon operations. First, if reasonably heavy snow is to be expected, the airplanes entering or leaving the airport must be equipped for landing upon or taking off from the surface of the snow. Occasionally sleet or snow freezes on the wings of an airplane flying through a storm and sometimes seriously decreases its maneuverability through overloading. Flying in rain during cold weather often produces a similar effect. Even a light snowfall may change the appearance of the surroundings of the airport and make it difficult for the pilot to locate it. Viewed from the angle of airport selection, there will be so little variation between sites in any given locality that snow, like rain, will make itself felt mainly in connection with the drainage problem. Heavy snowfall will necessitate better drainage. However, the possibility of snowdrifts should be considered although the influence of snow will be more observed in selection of operating equipment than in selection of the airport site. Temperature is another element which will offer no choice, but it must be taken into consideration as affecting heating of buildings and, if the airport is to provide for seaplanes, the possibility of ice coating on the take-off stretch must be considered.

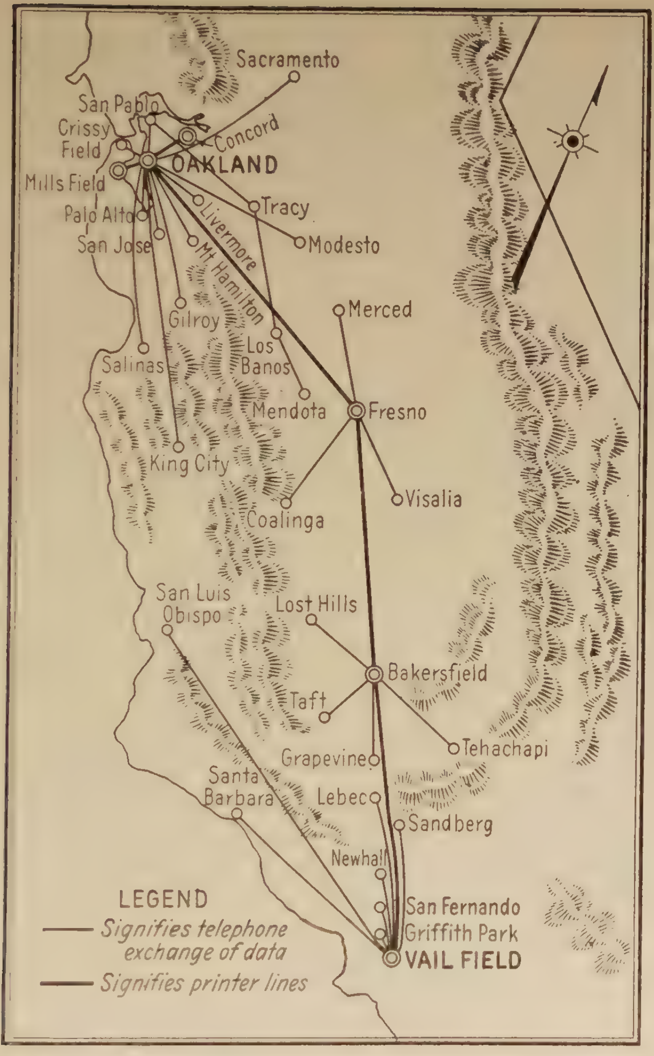

Fig. 76.—Diagram of reporting system used by the experimental aviation weather service organized in California by the Guggenheim Fund for Promotion of Aeronautics.

Local Variations from Weather Records.

In consideration of Weather Bureau records and their application to selection of airport sites it is necessary to express a word of caution on the possibility of local variation. If the Weather observation station is located at some distance from the contemplated airport, or if the surrounding conditions are not similar, it may be necessary to modify the records. In a few cases it may be advisable to take some observations at the site to determine the possible extent of this local variation, if any. Cases of variation may occur where the airport is located in a valley, or surrounded by buildings and sources of smoke, or perhaps located adjacent to a large body of water, while the surroundings of the weather station are not comparable. A range of hills is liable to affect the direction of winds; the proximity of swamps may give rise to ground fog; large bodies of water may cause frequent fogs; groups of trees and other formations may create gusty local winds which make use of the site undesirable. The only means of protection against these dangers is investigation of the actual site by an experienced meteorologist.

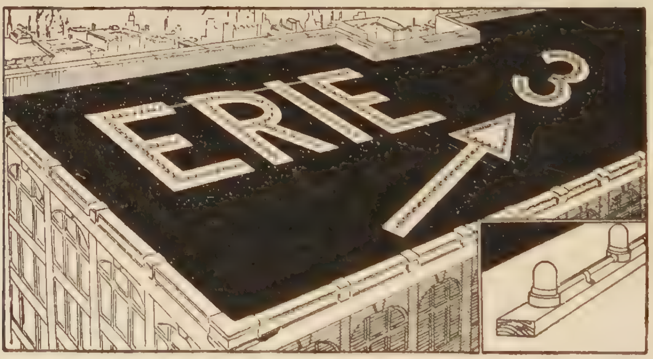

Fig. 77.—Illuminated roof signs for guiding pilots can be inexpensively constructed as shown in the lower right hand sketch above.

Work of the Guggenheim Fund.

The Daniel Guggenheim Fund for Promotion of Aeronautics in cooperation with the Pacific Telephone and Telegraph Company, the Aeronautics Branch of the Department of Commerce and the Weather Bureau of the Department of Agriculture has organized an experimental airways meteorological service in central and southern California. This service as organized collects observations at 30 points distributed throughout California, and these reports are collected at regular intervals at the terminal stations at Oakland and Los Angeles airports. The observation stations were placed to give weather information along a number of alternative courses along the air route. The service is financed mainly by the Guggenheim Fund for the purpose of providing an experimental laboratory for study of day-to-day flying conditions with a view towards improvement of aviation meteorological practice.

APPENDIX

Appendix 1—*Housing Dimensions of Some Typical American Commercial Airplanes.*

Land Types	*Width Over All*	*Length Over All*	*Height Over All*
Alexander Eaglerock OX	36′-8″	24′-11″	9′-11″
Boeing 40-C	44′-2″	33′-4″	11′-8″
Curtiss Robin	41′-0″	25′-9″	7′-10″
Fairchild FC-2W2	50′-0″*	32′-10″	9′-4″
Fokker F-7 or C-2	63′-3″	49′-2″	12′-9″
Fokker F-10	71′-2″	50′-8″	12′-5″
Fokker Universal	47′-9″	33′-0″	8′-9″
Ford Stout 4 AT	74′-0″	49′-10″	12′-8″
Keystone Pathfinder	66′-6″	46′-0″	
Pitcairn Mailwing	33′-0″	22′-10″	8′-10″
Sikorsky S-37	100′-0″	45′-6″	16′-3″
Stinson SM-1B	45′-10″	32′-0″	9′-0″
Travel Air 4000	34′-8″	23′-6″	8′-9″
Travel Air 6000	48′-7″	30′-11″	
Waco 10-OX	30′-7″	23′-6″	9′-0″
Water and Amphibian Types			
Boeing B-1E	39′-8″	32′-6″	12′-0″
Fairchild FC-2W2	50′-0″*	37′-2″	11′-7″
Ireland Neptune	40′-0″	31′-6″	11′-6″
Loening Cabin	45′-0″	34′-8″	13′-2″
Sikorsky S-36	72′-0″	34′-0″	12′-0″

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* With wings folded width about 11′-9″

Based largely upon tabulations published in *Aviation.*

*Appendix 2—Airport Maintenance and General Equipment**.

Heating system.
Electric power plant (where no other supply).
Hand fire extinguishers.
Fire engine.
Fire alarm.
Tractor with flat wheels.
Grass cutter for tractor.
Road drag for tractor.
Snow plow for tractor.
Roller for snow packing.
Light truck.
Field office furniture.
Auto jack and small tools.
First-aid kit.

*Appendix 3—Servicing Equipment for Airports**.

Gasoline storage tanks with pump.
Oil-barrel rack or tank.
Portable oil tank with pump.
Safety gasoline can.
Self-closing waste cans.
Water storage system (where no running supply).
Tire pump, preferably power.
Oil and water heaters.
Storage battery charger.
Clothes and tool lockers.
Tarpaulin covers.
Towing and mooring ropes.
Handling dolly.
Screw post-anchors for airplane tie-down.
Wheel chocks.

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* These lists are all-inclusive and to be selected from in compiling equipment lists for a project. Repair equipment is not included, being covered in Appendices 5 and 6.

Seaplane handling truck.
Mooring buoys.
Marine anchors.
Beaching tracks or ways.
Crab, winch, capstan or crawler tractor for hauling out seaplanes.
Small power boat with service gasoline tank, etc.

Appendix 4—*Airports Operating Equipment**.

Wind indicator.
Megaphone.
Signal lights or flares.
Landing lights.
Boundary lights.
Obstacle lights.
Ceiling projector.
Beacon.
Rain gauge.
Wind speed indicator.
Barograph or barometer.
Thermograph or thermometer.
Telephone connection.
Radio telephone or telegraph.
Traffic control office.
Traffic control system.

Appendix 5—*Airplane Repair Equipment.*

Carpenter's small tools.
Carpenter's benches.
Circular saw.
Band saw.
Ceiling-fastened jig saw.
Double-spindle shaper.

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* These lists are all-inclusive and to be selected from in compiling equipment lists for a project. Repair equipment is not included, being covered in Appendices 5 and 6.

Jointer.
Planer (wood).
Fuselage jigs or benches.
Wing jigs or benches.
Electric hand drill.
Glue pots.
Steam box.
Sewing machine (for fabric wings).
Exhaust fan for dope room.
Portable vacuum cleaner (for cleaning fuselages).
Propeller-balancing stand.
Balancing mandrils for propellers.
Propeller checking table.
Radiator testing equipment.
Sheet-metal workers' small tools.
Soldering-iron heater.
Small sheet-metal beader.
Sheet-metal profile cutter.
Cable terminal wrapper.
Hard-wire loop bender.
Wire and cable proof loader.
Pipe bender.
Acetylene welding set.
Blacksmith's forge.
Blacksmith's anvil (about 200 lbs.)
Power hacksaw.
Vertical drill.
Power grinder.
Wheel repair stand.
Dihedral checking level.
Two-way builder's level.
Wing panel trailer.
Riveting equipment for metal wing repairs.

NOTE: This is a fairly inclusive list; airport needs will vary with the volume and type of work.

Appendix 6—Engine Maintenance and Repair Equipment.

Engine overhaul stand.
Chain block.
Tracks for chain block.
Special tools for each type of engine.
Machinist's small tools.
Small arbor press.
Kerosene washing pans.
Ignition-testing setup.
Piston and rod alignment jig and straightening tools.
Valve-truing tool.
Main-bearing line reamer (for some types).
Compressed-air system for cleaning parts with bench hoses.
Kerosene pressure-spray system for cleaning parts.
Gear pulling clamp.
Machinist's benches.
Piston and rod scales.
Screw-cutting lathe.
Stationary oil can with faucet or pump.
Engine test stand.

NOTE: This is a fairly inclusive list; airport needs will vary with the volume and type of work.

Appendix 7—Characteristics of Fire Extinguishers

TYPE			FOAM	SODA-AND-ACID	ANTI-FREEZING	TETRACHLORIDE
CHEMICALS EMPLOYED			Aluminum Sulphate—Bicarbonate of Soda with Foaming Agent	Bicarbonate of Soda Sulphuric Acid	Calcium Chloride	Carbon Tetrachloride with components for depressing freezing point, avoiding corrosion, etc.
USUAL METHOD OF OPERATING			INVERT	INVERT	INVERT OR PUMP	PUMP
METHOD BY WHICH PRESSURE IS CREATED			CHEMICAL REACTION	CHEMICAL REACTION	CHEMICAL REACTION BURNING OF SAFETY FUSE OR PUMPING ACTION	PUMPING ACTION
EFFECTIVE RANGE OF STREAM			30 to 40 FEET	30 to 40 FEET	30 TO 40 FEET	20 FEET OR MORE under full pump pressure
RATED LIQUID CAPACITY OF MOST COMMON SIZE			2½ GALLONS	2½ GALLONS	2½ GALLONS	¼ GALLON
QUANTITY OF PRINCIPAL EXTINGUISHING AGENT PRODUCED			20 GALLONS	2½ GALLONS	2½ GALLONS	Volume depends upon amount of liquid which comes in contact with heat of fire.
NATURE OF PRINCIPAL EXTINGUISHING AGENT			FOAM— a mass of bubbles filled with carbon dioxide	LIQUID soda solution	LIQUID calcium chloride solution	FREE GAS produced when liquid is vaporized by heat of fire.
PRINCIPAL EXTINGUISHING EFFECT			BLANKETING	COOLING	COOLING	BLANKETING
RECOGNIZED AS ADAPTED FOR USE ON	Class A Fires	Wood, Textiles, Rubbish, Etc.	YES for use in all places involving Class A fires. Must be kept in heated cabinet when installed in places subject to freezing temperatures.	YES for use in places *not* involving oils, greases, etc., in any way. Must be kept in heated cabinet when installed in places subject to freezing temperatures.	YES for use in places *not* involving oils, greases, etc., in any way. DOES NOT REQUIRE PROTECTION AT TEMPERATURES DOWN TO 40 DEGREES BELOW ZERO.	NO other types are better adapted for class A fires.
	Class B Fires	Oils, Greases, Etc.	YES for use in all places involving class B fires. Must be kept in heated cabinet when installed in places subject to freezing temperatures.	NO because ordinarily it has little or no blanketing effect.	NO because it has no blanketing effect.	YES but other types are better adapted for class B fires.
	Class C Fires	Electrical Machinery	NO except on low voltage when used with caution, or where current is likely to be turned off. Stream is a conductor but a poor one.	NO except on low voltage when used with caution, or where current is likely to be turned off. Stream is a conductor but a poor one.	NO except on low voltage when used with caution, or where current is likely to be turned off. Stream is a conductor but a poor one.	YES for class C fires, especially in places where current is not likely to be turned off, because the stream is a non-conductor.
	Class D Fires	Pleasure Autobiles, Commercial Trucks Etc.	NO because of size; not splash-proof; subject to freezing.	NO because of size; not splash-proof; subject to freezing.	NO because of size; not splash-proof.	YES for class D fires because of desirable characteristics not possessed by any other type.
UNDERWRITERS' RATING			A1-B1	A1	A1	B2—C2—D1

Appendix 8—Dictionary of Airport and Airway Terms.

(Including portions of the standard nomenclature for aeronautics approved by the National Advisory Committee for Aeronautics.)

Aeronautics—The science and art pertaining to the flight of aircraft.

Aerostation—The art of operating "lighter-than-air" or buoyancy aircraft, such as airships and balloons.

Aircraft—Any weight-carrying device or structure designed to be supported by the air, either by buoyancy or by dynamic action. This term includes airplanes, airships, balloons and all other types.

Airdrome—A British term for an airport.

Air harbor—A Canadian term for an airport.

Airline—An organization operating aircraft, more or less regularly, over a prescribed course.

Airplane—A mechanically-driven aircraft, heavier than air, fitted with fixed wings and supported by the dynamic action of the air.

Airport—A locality, either of water or land, which is adapted for the landing and taking off of aircraft and which provides facilities for shelter, supply and repair of aircraft; or a place used regularly for receiving or discharging passengers or cargo by air.

Air Service—An organization operating aircraft, usually over other than prescribed courses and without regular schedules.

Airship—Any type of aircraft deriving its support mainly from the lifting effort of lighter-than-air gases and which has also some means of propulsion and control.

Airship station—The complete assembly of sheds, masts, gas plants, shops, landing fields and related equipment required to operate airships and supply their needs. A station may include all or a part of the items enumerated. The base from which airships are operated.

Air station—The generic term applied to any stopping place for aircraft of any type and which is provided with facilities for their reception and servicing.

Air terminal—A main airport.

Airway—An air route between traffic centers which is over terrain best suited for emergency landings, with landing fields at intervals, equipped with aids to air navigation and a communication system for the transmission of information pertinent to the operation of aircraft.

Anchorage, snatch block—An anchorage set in the ground for a snatch block used with a yaw line from a mooring mast. These anchorages may be of concrete or timber and are usually arranged at equal intervals around the circumference of a circle in the center of which is the mast; may also be applied to any anchorage for a snatch block used in hauling down an airship.

Apron—A hard-surface area immediately in front of the entrance of a hangar or aircraft shelter and which is used for the handling of aircraft or for repair in good weather.

Arresting gear—A device for arresting the forward motion of airplanes after landing.

Aviation—The art of operating heavier-than-air craft.

Balloon—A buoyancy or "lighter-than-air" type of aircraft without any mechanical means of propulsion.

Balloon bed—A mooring place on the ground for a captive balloon.

Beacon—A powerful light used to mark air routes or airports at night. A device emitting radio waves for the guidance of aircraft.

Blimp—A small non-rigid airship. The term "airship" generally used and is considered better practice.

Catapult, airplane—A device for facilitating the launching of airplanes by utilizing the principle of a catapult.

Dirigible—Steerable, as a dirigible balloon. Its use as a noun to indicate an airship is incorrect.

Dock—A term sometimes applied to an airship shed.

Docking rail—A rail or guide, constructed on the landing field and extending into the shed, which supplies a means for holding the lateral pull of an airship's docking or handling lines. The pull is transmitted to the rails from wheeled cars or trolleys which are fitted on or in the rails. Usually two rails are fitted at the greatest distance apart which will permit them to be run into the shed or hangar.

Docking trolley—The car or trolley used in conjunction with docking rails for handling of airships. See docking rail.

Dolly—A small truck used to facilitate the handling of airplanes on the ground, generally by carrying the weight of the tail.

Fairway—The clear stretch of water, in the proximity of an airport, which is used for the take-off and landing of seaplanes.

Flattening out—The act of flattening the glide of an airplane just before effecting a landing.

Flying boat—A type of seaplane utilizing a boat-like hull which serves the purpose of a body as well as furnishing floatation while on the surface of the water.

Ground flare—A light, usually produced by combustion of a cartridge, used for signalling to aircraft from the ground at night.

Ground gear—The gear, or equipment, necessary for the landing and handling of an airship on the ground.

Ground organization—The ground facilities and non-flying personnel used in the operation of aircraft.

Handling rail—See docking rail.

Handling truck—A truck, mounted on wheels or sliding on slipways, on which seaplanes may be carried to facilitate moving them about, carrying them to and from their hangars and launching or hauling them out of the water.

Hangar—A shelter for housing aircraft, usually a building excepting in cases of temporary housing, when a tent is sometimes used. Buildings used for housing airships and balloons are usually termed "sheds."

Landing field—A field of such a size and nature as to permit of aircraft landing and taking off in safety. It may or may not be part of an airport.

Landing field, intermediate (or emergency)—A field, on an airway, which is adapted for the landing and taking off of aircraft, but which is not equipped with facilities for shelter, supply and repair of aircraft and is not used regularly for the receipt or discharge of passengers or cargo by air.

Landing floodlight—A floodlight used at airports for illumination of part or all of the landing area during night landings. One large unit or a battery of lesser units may be utilized.

Landing ground lights—A system of lights, on the surface of the landing area, which is used at some European airports to indicate at night the direction of the wind and the point at which the landing should be effected. This method is not used in the United States.

Landing run—The run of an airplane over the ground, or surface of the water, while losing its momentum after effecting a landing.

Landing T—A large symbol, shaped like a capital T, which is laid out on a landing field or on the top of a building to guide flyers in landing and taking off. Usually automatic in operation, being actuated by the wind in such cases.

Landplane—An airplane designed to rise from and alight on the land.

Launching ways—Paths or tracks running from the shore out into the water and used for the launching or hauling out of seaplanes. Sometimes called "slipways," "ways" or "runways." See also marine railway.

Main door—The large door of a hangar through which aircraft are moved into or out of the building.

Marine railway—A rail track running from the shore out into the water and used for the launching or hauling out of seaplanes or boats by means of a car adapted to carry the seaplane or boat.

Marker, field—A sign provided at an airport or emergency landing field to indicate the center of the best landing area; sometimes also arranged to indicate the direction of best landing runways.

Marker, international—A sign used to facilitate identification of a town or locality from the air and which is constructed in accordance with the provisions of the International Air Convention. Not used in the United States.

Mooring drag—A movable, and/or, variable weight suspended from the after part of an airship's structure while moored at a mast, to aid in restraining the vertical and lateral motions of the stern of the airship.

Mooring line—A line attached at or near the bow of an airship for securing it to the ground or to a mooring mast.

Mooring mast—A mast or tower at the top of which there is mounted a fitting, so that the bow of an airship may be secured. It is usually provided with a ladder or staircase and a platform at the top, so that crew and passengers may enter or leave the airship, and also with piping for the supply of fuel, gas and water. Sometimes called "mooring tower."

Mooring ring—A metallic ring suspended from one of the forward frames of a rigid airship by wire lines and used for mooring. A ring set into the surface of a landing field for use in mooring airships or tying down airplanes.

Mooring space—An area on water or land used mainly for mooring of aircraft.

Mooring tower—See: mooring mast.

Obstruction light—A light used to mark obstructions to aerial navigation at night, usually in the vicinity of an airport.

Overhead suspension—A line leading from the roof of an airship shed or hangar and arranged to sustain the whole or a part of the weight of the structure of an airship when it is docked.

Parachute flare—A light, produced by the combustion of a cartridge, carried by a parachute and designed for dropping from an aircraft to render a large area of the ground below visible at night. Generally used for the purpose of finding a landing place when ground lights are not available.

Porpoising—The action of a seaplane in hopping from the crest of one wave to that of another while moving on the surface of the water at high speed.

Ram—A type of shock-absorbing device mounted at the top of a mooring mast, as part of the mooring mechanism, and arranged to ease the shock of contact when a mooring is being effected.

Runway—A specially surfaced portion of a flying field which is used frequently for take-off or landing of airplanes.

Seaplane—Any airplane designed to rise from and alight on the water. This general term applies to both boat and float types, although the boat type is usually designated as a "flying boat."

Service float—A float used for the servicing of seaplanes; usually carrying gasoline storage tank and having storage space for other supplies. Service floats are sometimes secured to the end of a pier and in other cases are anchored out from the shore.

Shed—A building for housing airships.

Side-slip landing—A type of landing in which an airplane is allowed to slip sideways, during part of the glide to the surface, in effecting a landing. The angle of glide is thus increased without increasing the speed, enabling the landing to be made in a shorter distance than would otherwise be necessary. Of chief value where the landing area is very limited, as at an emergency landing field.

Snatch block anchorage—See: anchorage, snatch block.

Take-off run—The run of an airplane, during acceleration from a standstill to flying speed, when taking off.

Taxi—To run a landplane over the ground, or a seaplane on the surface of the water, under its own power.

Three-point landing—The landing of an airplane in which contact with the surface is made with three points at once; in the case of a landplane with the two wheels and tail skid touching the ground at the same time.

Three-point mooring—A system of mooring airships in which three lines run from a common point on the airship to three points on the ground so that movement of the airship is restricted. Generally considered as an emergency substitute for a mooring mast.

Wheel chock—A block used to prevent the wheels of airplanes from rolling while the engine is being operated (such as for "warming up") when the machine is on the ground.

Wind cone—A conical, tubular streamer with an open end and which is flown from the top of a mast to indicate the direction of the wind at airports. Often called a "sock."

Wing-tip light—A light carried under the wing tips of an airplane and designed for illuminating the ground, or surface of the water, below when a night landing is being made.

Yaw line—A line dropped from the bow of an airship, when mooring to the mast, to act as a steadying line to prevent yawing and overriding the mast.

Appendix 9—Airport Rating Regulations of the U. S. Department of Commerce, Aeronautics Branch, Washington, D.C.

CAUTION: These regulations are as amended January 1, 1929, and as in effect up to February 1, 1929. Some slight changes are understood to be pending as this volume goes to press.

PART 1. GENERAL PROCEDURE, PENALTIES, AND WAIVER OF REGULATIONS.

GENERAL PROCEDURE

SECTION 1. The Secretary of Commerce will rate airports of the United States as to their suitability upon application of the owner of these facilities. Such application must be made in duplicate on the form provided by the Department of Commerce.

The owners of all such airports found suitable for use by aircraft of the United States after due investigation by the Secretary of Commerce will be issued a rating certificate which will identify such facilities as hereinafter provided. Such certificates will be issued for an indefinite period unless specifically revoked. Annual reports covering the condition of the facilities and describing any material change shall be rendered in duplicate to the Secretary of Commerce at such time as he may designate and on the form provided by the Department of Commerce.

Major changes on rated airports shall not be made without approval of the Secretary of Commerce. Any such change of the facilities will automatically cancel the certificate unless such change has the prior approval of the Secretary of Commerce. The decision of the Secretary of Commerce as to what constitutes a major change shall be final.

As used in these regulations, the words "Secretary of Commerce" shall be interpreted to include the duly authorized representative of the Secretary of Commerce, and the acts of such representative shall have the same force and effect as though performed by the Secretary in person.

The airport ratings will be based on the requirements hereinafter set forth and will be indicated in each case by a letter, a figure, and a letter. The first letter will indicate the general equipment and facilities at the airport; the figure will indicate the effective landing area; and the second letter will indicate the night lighting equipmnt. The order will be letter, figure, letter, as A 1 A, which is the highest rating given.

When ratings are revoked, the rating certificate shall be returned immediately to the Secretary of Commerce.

PENALTIES

SECTION 2. Any person who fraudulently forges, counterfeits, alters, or falsely makes any certificate authorized to be issued under the act, or knowingly uses or attempts to use any such fraudulent certificate, shall be guilty of an offense punishable by a fine not exceeding $1,000 or by imprisonment not exceeding three years, or by both such fine and imprisonment.

Any person (1) who, with intent to interfere with air navigation in the navigable air space or waters of the United States, exhibits within the United States any false light or signal at such place or in such manner that it is likely to be mistaken for a true light or signal required by regulations under this act, or for a true light or signal in connection with an airport or other air navigation facility, or (2) who, after due warning from the Secretary of Commerce, continues to maintain any false light or signal, or (3) who knowingly removes, extinguishes, or interferes with the operation of any such true light or signal, or (4) who without lawful authority knowingly exhibits any such true light or signal, shall be guilty of an offense punishable by a fine not exceeding $5,000, or by imprisonment not exceeding five years, or by both such fine and imprisonment.

WAIVER OF REGULATIONS

SECTION 3. The Secretary of Commerce may waive any of the requirements of these regulations when, in his discretion, the particular facts justify such waiver. The letter or figure covering the part of the rating under which requirements have been waived will be underscored. For instance, an airport bearing the rating "A 1 A" will not have fully met the requirements for a "1" Rating on size of landing area, but will have been granted this rating because of some special condition impossible of change and which is believed by the Secretary of Commerce to be fully compensated by other conditions.

PART II. RATING OF AIRPORTS FOR LANDPLANES

BASIC REQUIREMENTS

SECTION 4. The minimum basic requirements for the rating of airports are as follows:

(a) Suitable landing area.—The airport shall afford a firm, smooth, well-drained landing area, approximately level, without obstructions or depressions presenting hazards in taking off or landing, and with suitable approaches. If sufficient area is not available for landing and taking off in all directions, there shall be at least two landing strips 500 feet or more in width crossing or converging at an angle or not less than 60°. The landing area shall permit safe landing and taking off under all ordinary weather conditions. If the surface of the landing area is not sufficiently firm and well drained for this purpose, runways shall be constructed as hereinafter specified. Roads shall not cross any part of the landing area, whether open field or landing strips, and stock and unauthorized persons and vehicles shall not be allowed on the landing area as this area must be kept clear and ready for use at all times. The maximum slope of the landing area shall at no point exceed 3 inches in 10 feet, which corresponds to a grade of 2½ per cent. The mean slope of the landing area shall not be more than 2 per cent in any direction.

(b) Freedom from obstructions.—For fields located at sea level, surrounding obstructions diminish the effective landing lengths for planes landing or taking off over these obstructions by amounts equal to seven times the height of the obstructions above the landing area, said distances being measured, in each case, horizontally from vertical lines passing through the critical points of the obstacles. For instance, obstacles 50 feet high along the border of a field diminish the effective landing length for planes landing or taking off over these obstacles by 350 feet. In the case of landing strips, the presence of obstacles in the approaches will likewise diminish the effective lengths of the landing strips. Where obstacles lie alongside the landing strips, so that planes landing pass parallel to and not over them the obstacle rule of 7 to 1 will not apply, providing that no landing strip shall be less than 500 feet wide, in accordance with paragraph (a) of basic requirements. However, the location of buildings or other obstructions in the V formed by landing strips or runways is subject to a number of objections.

For fields located at altitudes in excess of 1,000 feet above sea level, the allowable safe climbing ratios for clearing obstructions shall be increased from the value of 7 to 1 used at sea level to the values shown in Figure 1. (At altitudes above sea level, airplanes land and take off at higher speeds and climb at flatter angles than at sea level.)

(*Author's note: Figure* 1 *of these regulations is not yet available as this volume goes to press.*)

(c) Accessibility.—The airport shall be situated on a good road leading to the nearest city or town.

(d) Wind direction indicator.—The airport shall be equipped with an approved type of wind direction indicator, as hereinafter specified.

(e) Markings.—The landing area shall be marked by means of a circle at least 100 feet in diameter having a band 4 feet wide, constructed of crushed rock, gravel, or other suitable material. The circle shall be finished flush with the surrounding surface and unless constructed of a bright white material shall be kept whitewashed or painted chrome yellow. In case the circle is constructed of concrete or other similar material, shoulders of some granular material, such as crushed stone or crushed slag, or other suitable means shall be provided on both the inside and outside of the circle in order to insure the safe landing and taxiing of planes across the circle in any direction.

The name of the city or town shall be placed near the marker circle (name should not be placed inside of circle) or on the roof of at least one airport building, or on other suitable area, in such manner as to be visible from an altitude of at least 2,000 feet. (Lettering should be from 10 to 30 feet in height as space may permit). In no case shall the height of the lettering be less than 6 feet. In case the name of the city or town or any other marking is placed on the landing area, it shall be constructed and maintained in the manner hereinabove required for the marker circle.

(It is recommended that, wherever practicable, a combination of chrome yellow and dead black be used in air-marking roofs and other similar areas and that, particularly in cases where the markings are to be illuminated, the chrome yellow be used for the lettering and other symbols, and the dead black for the background).

The outline of the usable portion of the landing area shall be marked by means of painted galvanized sheet-metal cones not less than 36 inches in diameter at the base by 24 inches in height, or solid 4-foot white or chrome yellow circles constructed of crushed stone, gravel, or other suitable material, or by means of other markers of equivalent effectiveness, placed not more than 300 feet apart along the borders and kept whitewashed or painted. In case the landing area is boundary-lighted the markers shall be constructed around the boundary lights. In case sheet-metal cones are used, they should be painted in accordance with the following standard system of marking:—For either white or yellow lights, chrome yellow with an 8-inch horizontal dead black stripe 9 inches from the base of the cone. For green lights, eight equal segmental elements alternating chrome yellow and dead black, each element covering a 45-degree segment of the surface. For red lights, light vermilion with an 8-inch horizontal white stripe 9 inches from the base of the cone. These figures are for cones measuring 36 inches in diameter at the base by 24 inches in height; if cones of larger dimensions are used the width of horizontal stripe and height of stripe above base of cone should be varied accordingly.

Any parts of the landing area temporarily unsafe for landing, or which are not available for any cause, shall be clearly marked with red flags of sufficient size to draw attention readily and so placed as to show the boundaries of the danger area. In case the airport is lighted for night operation the boundaries of such danger area shall be clearly marked throughout the hours of the night (from sunset until sunrise) either with red electric lights with weatherproof fittings or with red lanterns.

(f) Runways.—Runways shall be constructed of some wear-resisting material, such as crushed stone, crushed slag, or other suitable material, in such a manner as to give a smooth, firm, uniform surface. (This includes such types of construction as bituminous macadam, bituminous concrete, Portland cement concrete, etc.) Runways shall be so designed and constructed as to withstand safely the loads to which they will ordinarily be subjected. They shall permit safe landing and taking off under all ordinary weather conditions and shall be not less than 100 feet in width. The edges of the runways shall be flush with the adjacent surfaces of the field, and shoulders of some granular material, such as crushed stone or crushed slag, or other suitable means shall be provided in order to insure the safe landing and taxiing of planes across the runways in any direction.

(g) Drainage.—The landing area shall be adequately drained whether runways are used or whether the entire field is available for landing and taking off. If the natural drainage is sufficient, no artificial drainage system will be required.

(h) Fuel, communication, transportation, and personnel.—The airport shall be provided with facilities for supplying aircraft with fuel, oil, and water, also drinking water shall be available. If there are no rest-rooms on the airport a suitable latrine shall be provided. The airport shall have dependable communication and transportation facilities to the nearest city or town. Airport personnel shall be in attendance by day or available on call by telephone at the airport. In the latter case, a directory and full instructions for reaching such personnel shall be available in the telephone booth or receptacle.

RATING ON GENERAL EQUIPMENT AND FACILITIES

SECTION 5. "A" rating.—In addition to the facilities named in the basic requirements, airports receiving an "A" rating on general equipment and facilities shall have the following:

(a) At least one hangar measuring not less than 80 feet by 100 feet in the clear inside with doors open, with 18-foot overhead clearance, with full-width door opening in either one or both ends or one or both sides, and with safe provision for heating water and oil. In localities where freezing temperatures are experienced the hangar shall be heated sufficiently to prevent freezing of water.

(b) One or more wind-direction indicators of an approved type, equivalent in effect to a wind cone not less than 12 feet long, 36 inches in diameter at the throat, 12 inches in diameter at the tail, constructed of open-weave unbleached yellow muslin, and so mounted as to fly freely with the wind. This wind-direction indicator shall be so located as to give a true indication of the direction of the wind on the landing area and as to be readily visible to aircraft approaching the airport from any direction. In case it is not visible to aircraft approaching from any direction such additional wind-direction indicators shall be installed as may be necessary.

(c) All telephone and transmission line poles, radio towers and masts, transmission towers, flag poles, and similar obstructions in the immediate vicinity of the airport shall be day-marked by painting with alternate bands of either chrome yellow and dead black, or white and dead black, terminating with either a chrome yellow or a white band at the top, depending on the color combination used. The width of the bands shall be one-fifth of the height of the structure for all structures less than 250 feet high and for structures over 250 feet high, the bands shall be fifty feet wide. Such structures as chimneys and water towers in the immediate vicinity of the airport are not required to be painted in this manner unless, in the opinion of the Secretary of Commerce, such painting is necessary from the standpoint of safety.

The posts of landing area fencing shall be painted either chrome yellow or white.

(d) Repair equipment sufficient to permit changing of engines and landing gear and equipment for major engine and plane repairs.

(e) Weather instruments, including an anemometer, barometer, and thermometer. There shall also be a bulletin board and facilities for giving pilots the most recent weather information.

(f) Radio-receiving set and loud-speaker, under certain conditions, as follows:—Airports located within a radius of 400 miles of Department of Commerce Airways radio stations shall be equipped with suitable radio-receiving sets with loud-speakers, in order that those using the airport may avail themselves of the hourly weather reports broadcast from said stations. As additional Airways radio stations are installed by the Department of Commerce, airports located within a radius of 400 miles of such stations and previously granted an "A" rating on general equipment and facilities shall provide themselves with suitable radio-receiving sets and loud-speakers in order to retain this rating.

(g) Adequate equipment for removing snow from landing areas or landing strips or equipment for packing snow sufficiently to permit safe landing and taking off of aircraft. (This will not be required at airports where snowfall is never sufficient to cause difficulty in operation).

(h) First-aid equipment consisting of an ambulance, or some vehicle which can be used as an ambulance, equipped with the following: First-aid kit, drinking water, crowbar, wire cutters, hack saw, axe, cloth-cutting shears, fire extinguisher, two litters.

The first-aid kit should contain 12 assorted bandages, 12 sterile dressings, 2 tourniquets, a supply of first-aid dressings for burns, adhesive tape, a supply of either tincture of iodine or mercurochrome, aromatic spirits of ammonia, and a paper or glass cup.

The litters should preferably be of the Stokes Navy type. If they are of the ordinary type, then the vehicle should also carry an assortment of splints.

(i) A register of arriving and departing aircraft to include the following information:

1. License number and model of arriving or departing plane.
2. Owner of plane.
3. Pilot of plane and his license number.
4. Time of arrival and departure.

5. Number of crew.
6. Number of passengers.
7. Space for remarks covering an unusual situation.

(j) Adequate fire-fighting equipment. As this depends on the size and number of buildings, spacing of structures, type of construction, etc., no definite rule can be made which will apply to each case, but such rating will depend upon recommendation of the department representatives, who will be guided in a large measure by the standards of the National Board of Fire Underwriters.

(k) Sufficient personnel in attendance throughout the day to give proper operation of the airport, including servicing aircraft, making major repairs, giving weather service, and operating the fire-fighting equipment.

(l) Sleeping quarters for at least three men, in addition to the field personnel, at the airport or not more than one-half mile distant.

(m) Waiting and rest rooms on the field.

(n) A restaurant or other public source of food supply. (If not actually on the airport, this shall not be more than one-half mile distant).

"B" rating.—In addition to the facilities named in the basic requirements, airports receiving a "B" rating on general equipment shall have the following:

(a) At least one hangar measuring not less than 60 feet by 80 feet in the clear inside with doors open, with 14-foot overhead clearance, with full-width door opening in either one or both ends or one or both sides, and with provisions for heating water and oil as required for an "A" rating.

(b) Wind-direction indicator, day marking of obstructions, weather instruments, adequate equipment for removing snow, first-aid equipment, fire-fighting equipment, and a register, all as required for an "A" rating.

(c) Repair equipment sufficient to permit changing of engines and landing gear and equipment for minor engine and plane repairs.

(d) Sufficient personnel in attendance throughout the day to give proper operation of the airport, including servicing aircraft, making minor repairs, giving weather service, and operating the fire-fighting equipment.

(e) Sleeping quarters for at least two men, in addition to the field personnel, at the airport or not more than one-half mile distant.

(f) Rest room.

"C" rating.—In addition to the facilities named in the basic requirements, airports receiving a "C" rating on general equipment shall have the following:

(a) At least one hangar measuring not less than 50 feet by 60 feet in the clear inside with doors open, with 12-foot overhead clearance, with full-width door opening in either one or both ends or one or both sides, and with means for heating water and oil as required for an "A" rating.

(b) One or more wind-direction indicators as required for an "A" rating, except that wind cone shall be not less than 9 feet long, 24 inches in diameter at the throat, and 10 inches in diameter at the tail.

(c) First-aid equipment, fire-fighting equipment, and a register as required for an "A" rating. (The day marking of telephone and transmission line poles and similar obstructions in the immediate vicinity of the airport as required for the "A" and "B" ratings is not required for either the "C" or "D" ratings, but is most urgently recommended).

(d) Rest Room.

"D" rating.—Fields which do not possess sufficient general equipment to obtain A, B, or C ratings, but which meet the basic requirements, will receive a rating of "D" on general equipment.

RATING ON SIZE OF EFFECTIVE LANDING AREA

SECTION 6. "1" rating.—In addition to the basic requirements, an airport receiving a "1" rating on size of effective landing area shall have at least 2,500 feet of effective landing area in all directions, with clear approaches, and the field shall be in good condition for landing at all times; or it shall have landing strips not less than 500 feet wide, permitting landing in at least eight directions at all times, the landing strips not to cross or converge at angles of less than 40°, nor any one of the landing strips to be less than 2,500 feet in effective length, with clear approaches.

By clear approaches is meant absence of buildings, towers, and other obstacles over which a 7 to 1 glide or climb to or from the edge of the landing area would not be possible, and absence of smokestacks, towers, high-tension power lines, etc., which constitute menaces even though beyond the 7 to 1 ratio. (see Sec. 4 (b) for increase in allowable safe climbing ratio for altitudes in excess of 1,000 feet above sea level).

When the airport lies at an altitude in excess of 1,000 feet above sea level, the dimensions of the effctive landing area or the effective lengths of the landing strips shall be increased to the corresponding values shown in Figures 2 and 3.

(*Author's Note: These Figures correspond to Figures* 10 *and* 11 *in this volume.*)

"2" rating.—In addition to the basic requirements, an airport receiving a "2" rating on size of effective landing area shall have at least 2,000 feet of effective landing area in all directions, with clear approaches, and the field shall be in good condition for landing at all times; or it shall have landing strips not less than 500 feet wide, permitting landing in at least eight directions at all times, the landing strips not to cross or converge at angles less than 40° nor any one of the landing strips to be less than 2,000 feet in effective length, with clear approaches; or it shall have two landing strips, one aligned with the general direction of the prevailing wind, permitting at least four-way landing at all times and having clear approaches, the landing strips to be at least 500 feet wide and not less than 3,000 feet in effective length and not to cross or converge at an angle of less than 60°.

The dimensions of the effective landing area and the effective lengths of the landing strips shall be increased at altitudes above 1,000 feet to the corresponding values shown in Figures 2 and 3.

"3" rating.—In addition to the basic requirements, an airport receiving a "3" rating on size of effective landing area shall have at least 1,600 feet of effective landing area in all directions with clear approaches, and the field shall be in good condition for landing at all times; or it shall have landing strips not less than 500 feet wide, permitting landing in at least eight directions at all times, the landing strips not to cross or converge at angles less than 40° nor any one of the landing strips to be less than 1,600 feet in effective length, with clear approaches; or it shall have two landing strips, one aligned with the general direction of the prevailing wind, permitting at least four-way landing at all times and having clear approaches, the landing strips to be at least 500 feet wide and not less than 2,500 feet in effective length and not to cross or converge at an angle less than 60°.

The dimensions of the effective landing area and the effective lengths of landing strips shall be increased at altitudes above 1,000 feet to the corresponding values shown in Figures 2 and 3.

"4" rating.—In addition to the basic requirements, an airport receiving a "4" rating on size of effective landing area shall have at least 1,320 feet of effective landing area in all directions, with clear approaches, and the field shall be in good condition for landing at all times; or it shall have landing strips not less than 500 feet wide, permitting landing in at least eight directions at all times, the landing strips not to cross or converge at angles less than 40° nor any one of the landing strips to be less than 1,320 feet in effective length, with clear approaches; or it shall have two landing strips, one aligned with the general direction of the prevailing wind, permitting at least four-way landing at all times and having clear approaches, the landing strips to be at least 500 feet wide and not less than 1,800 feet in effective length and not to cross or converge at an angle of less than 60°.

The dimensions of the effective landing area and the effective lengths of the landing strips shall be increased at altitudes above 1,000 feet to the corresponding values shown in Figures 2 and 3.

"5" rating.—Airports not having areas meeting the minimum requirements for a "4" rating on size but which request rating, and which the Secretary of Commerce considers safe for the use to which they are being put, shall receive the rating of "5" on size of landing area.

"O" rating.—An airport which, in the opinion of the Secretary of Commerce, is unsafe for operation, but from which operations are nevertheless taking place and which requests a rating, will be rated "O" on size of effective landing area.

RATING ON NIGHT LIGHTING EQUIPMENT

SECTION 7. "A" rating.—Airports receiving an "A" rating on night lighting equipment shall have the following:

(a) An airport beacon.—The requirements for a satisfactory aeronautical beacon light for airports are adequate candlepower, not less than 100,000 for long range; proper distribution of light in the vertical plane to make the beacon visible all around the horizon and to the zenith, or nearly so, for altitudes of from 500 to 2,000 feet; distinctiveness for identification; flashes of not less than one-tenth second duration; luminous period of not less than 10 per cent; and eclipse periods of not more than 10 seconds duration.

Apparatus having characteristics other than above specified but of equivalent effectiveness owing to greater luminous periods and shorter eclipse periods, greater candlepower, or color effect, may be used. In no case, however, shall the beam candlepower be less than 15,000 nor shall the luminous period be greater than 60 per cent. For beacons of 30,000 candlepower or less the luminous period shall be at least 35 per cent. Beacons of less than 20,000 candlepower shall have a distinctive color characteristic. All flashing beacons shall have a definite Morse code characteristic and shall be operated by flashing mechanisms so designed as not to interfere with radio reception.

The beacon may have fixed lenses, or a combination of lenses, with a flashing light source; flash panel lenses; neon lights, with or without optical apparatus, to the equivalent specified above; or it may be a rotating beacon, making six revolutions per minute, with at least one parabolic reflector not less than 24 inches in diameter, or other equivalent optical apparatus, and a light source of not less than one 1,000-watt, 110-volt lamp or one 900-watt, 30-volt lamp. In the case of beacons having a single light source an automatic lamp changer for bringing a spare lamp into the focal position shall be provided or else there shall be an auxiliary beacon of at least 10,000 candlepower which is either kept in operation with the major unit or so designed as to be turned on automatically without interruption of service.

Wherever practicable the airport beacon shall be installed directly on the airport or immediately adjacent thereto and in such manner as to be visible in all directions. In case the topography of the surrounding terrain is such as to necessitate installing the beacon at some distance from the airport, there shall be installed on the airport a green, flashing, double light source auxiliary beacon of not less than 5,000 candlepower with a definite Morse code characteristic, or in lieu thereof, a white, flashing, double light source, auxiliary beacon of not less than 10,000 candlepower and with a definite Morse code characteristic. In no case, however, shall the distance from the main beacon to the nearest edge of the landing area of the airport exceed one mile.

(On the national airway system, flashing, red, course-lights are used at beacons where no landing fields are located, and flashing, yellow, course-lights are used at beacons where intermediate fields have been established. It is urgently recommended that green flashing, double light source, auxiliary beacons of at least 5,000 candlepower and with definite Morse code characteristics be installed on the airports in addition to the major airport beacons. It is suggested that, where practicable, the auxiliary beacons be installed directly above the major beacons. The uniform use of red, yellow, and green auxiliary beacons to indicate landing conditions would add materially to the safety of night flying).

(b) An illuminated wind-direction indicator.—There shall be at least one illuminated wind-direction indicator, internally or externally lighted, equivalent in effect to the wind cone described under the requirements for an "A" rating on general equipment and facilities. A lamp of not less than 200 watts with suitable reflector will be required for the internal lighting of this wind cone. For external lighting, a suitable system of lights and reflectors so mounted above the wind cone as to make it visible at night from a distance of 1,000 feet in any direction will be considered satisfactory.

(c) Boundary lights.—The outline of the usable portion of the landing area shall be shown at night by boundary lights spaced not more than 300 feet apart and served by an underground distribution system. Either series or multiple circuits may be used.

The cable used for boundary light circuits shall be insulated for at least the maximum open-circuit voltage obtainable on the circuit. The cable conductors shall be of copper, and for multiple circuits they shall be of such size that the voltage drop will not exceed 5 per cent of the normal operating voltage of the circuit, but in the case of neither series nor multiple circuits shall they be less than No. 8 B. and S. gauge. In the case of multiple circuits using either a 3-wire ring circuit or a straight 3-wire circuit, No. 10 B. and S. gauge bare copper wire may be used for the third conductor. Such cable and wire shall be installed at a depth of at least 10 inches unless otherwise protected by suitable mechanical means.

For series circuits having normal operating voltages in excess of 310 volts, a series transfomer (safety coil) shall be installed at the base of each boundary light standard to prevent accident through high-tension current in event of collision with the light. In the case of series circuits with operating voltages of 310 or less the use of such series transformers is not required, providing the maximum open-circuit voltage does not exceed 450 volts. A series circuit using two constant-current transformers with the secondary windings of these transformers connected in series and with both the point of connection between these two secondary windings and a suitable point in the circuit effectively grounded, or other equivalent installation, may be used without the series transformers (safety coils) providing the operating voltage and the maximum open-circuit voltage at any part of the circuit do not exceed 310 and 450 volts, respectively. (A grounded circuit should not be installed without first finding whether it is in keeping with the practice of the power company supplying the current).

Suitable weatherproof units with either plain or prismic globes are required for the boundary lights. On all series circuits these units shall be provided with cutout sockets. In event of lamp failure such sockets are necessary to re-establish the circuit in the case of straight series circuits and in the case of series circuits with series transformers (safety coils), to short-circuit the series transformer secondary. (An open-circuited secondary sets up electro-magnetic waves of such a frequency as to interfere with radio reception in the immediate vicinity).

Either white or yellow lights shall be used in the boundary light system, excepting as follows: Where the entire field is not available for landing in all directions at all times, green lights shall be so placed in the system as to indicate clearly the ranges of each landing strip or runway. Red lights shall be installed in the boundary system at points where an approach is particularly hazardous.

In multiple circuits, at least 25-watt lamps shall be used for white and yellow lights and at least 50-watt lamps for green and red lights. In the case of series circuits, S-24-½, 6.6-ampere, 600-lumen lamps shall be used for white and yellow lights, and 1,000-lumen lamps for green and red lights. Diffusing globes or frosted lamps shall be used for all white lights to prevent glare.

(d) Obstruction lights.—All obstructions on and in the vicinity of the airport shall be clearly marked with red lights of the same wattage or lumen output as the red lights specified for the boundary circuit. Suitable weatherproof units shall be used and shall be mounted in each case above the highest point of the obstruction, or on poles of corresponding height placed alongside thereof. The use of a flashing mechanism in connection with the obstruction lights is not required nor recommended; however, if such a mechanism is used it shall be so designed as not to interfere with radio reception in the vicinity.

In marking pole lines, an obstruction light shall be placed on each pole. (While not required by these regulations, it is very desirable from the standpoint of safety that two obstruction lights be placed on end poles and on corner poles; otherwise the burning out of the single light in such locations may lead to serious results). The lights marking such obstructions as a row of trees shall not be spaced more than 300 feet apart.

All tall, isolated obstructions in the vicinity of the airport exceeding 100 feet in height, such as radio towers and masts, flag poles, transmission towers, water towers, chimneys, and other tall structures, shall be marked with at least two red lights placed directly above the obstruction, and with one red light, or more, as may be necessary to give visibility in all directions, placed at two-thirds the height and also at one-third the height of the obstruction. In lieu of such red obstruction lights, chimneys, water towers, and similar structures may be marked by adequate floodlighting.

(e) Hangar floodlights and roof marking.—The exterior surface of each hangar on the airport shall be floodlighted to an average intensity of illumination of at least 2½ foot-candles. This may be accomplished by a system of at least 200-watt lamps with industrial reflectors mounted about 10 feet above the surface and spaced on 20-foot centers in each direction on the roof and along the eaves and ends of the roof, or by the use of floodlight projectors giving this specified intensity of illumination. Such projectors shall be so installed as not to produce a glare that will interfere with planes using the airport. The hangar floodlighting equipment shall be lighted at times when night landings are being made.

The exterior surfaces of the hangars excepting roof-areas used as the background for air markings, shall be of such color as to reflect not less than 50 per cent of the light and at least one hangar roof, or other suitable area, shall be marked with the name of the city or town in the manner set forth in Section 4 (e). Said marking shall be so illuminated as to be visible from an altitude of at least 2,000 feet. (In case the marking is illuminated by exposed incandescent lamps or by neon tubes, the lamps or tubes should preferably be placed along the center line of the strokes of the lettering and other symbols and the roof should not be floodlighted. For outlining with incandescent lamps, not less than 10-watt sign lamps should be used and they should be spaced from 8 inches apart for 6-foot letters, to 12 inches apart for 12-foot letters or larger. Neon tubes should be either 11-millimeter or 15-millimeter by either 18-milliampere or 25-milliampere red neon tubing. If the illumination of the marking is by floodlighting, either industrial reflectors or floodlight projectors may be used, and the intensity of illumination should be at least 10 foot-candles here and preferably 15 foot-candles).

(f) A ceiling projector.—For use as a ceiling projector there is required an incandescent searchlight with a parabolic reflector of not less than 12 inches in diameter and with at least a 250-watt lamp of the concentrated filament type used for spotlight or headlight service and a stray light shield giving a beam spread of not to exceed 7 degrees, or an equivalent apparatus. (Projectors limited to these minimum requirements will not necessarily be large enough to handle the needs of every airport. In some cases, depending upon local conditions, it may be necessary to use units up to 24 inches in diameter and with 1,000-watt lamps). The ceiling projector shall be mounted on a yoke with a quadrant or other suitable means for elevating and holding the light at the proper angle of elevation. In case the projector is used in such a manner as to necessitate the measuring of vertical angles, as inclinometer, transit, or theodolite shall be provided, or in lieu thereof, an alidade so graduated and installed as to give direct readings of the ceiling height.

(g) Landing area floodlight system.—This system, which may consist of one or more units, shall be such as to provide an even distribution of illumination (free from abrupt changes in intensity and from shadow areas over the entire usable portion of the landing area). There shall be sufficient intensity of illumination to reveal the details of the surface and make depth perception readily possible from a minimum altitude of 30 feet in the center of the lighted area. The minimum vertical plane intensity of illumination over the usable portion of the landing area shall not be less than 0.15 foot-candle.

The floodlight system shall be immediately available for use through the operation of control located at a convenient point and shall be sufficiently elaborate or flexible to permit landing under all conditions of wind direction without the necessity of landing directly toward the light source.

There shall be sufficient light to illuminate objects and obstacles in the immediate vicinity of the airport in the direction of the beam and the floodlight unit or units shall be so designed and installed as to eliminate glare and blinding of the pilot.

Units shall be mounted as low as possible consistent with the contour of the landing area, shall project a beam of small vertical divergence with sharp cut-off at the top and with top of beam as nearly parallel with and as close to the surface of the landing area as practicable When more than one unit is used each unit shall be separately fused or other suitable provision shall be made to prevent a short circuit in one unit from interrupting service of other units. In lighting areas of irregular, wavy, contour, the units shall be so placed as to eliminate shadows.

Where the floodlighting is accomplished from a single light source, an automatic lamp changer shall be provided to bring a new lamp into the focal position in case of lamp failure. This lamp changer shall be so designed that the reserve lamp is ready to be placed immediately on the line. In lieu of a lamp changer an auxiliary unit may be provided which will give sufficient light for safe landing of aircraft should the major unit fail, and which will produce a minimum vertical plane intensity of illumination of not less than 0.035 foot-candle over the usable portion of the landing area. This auxiliary unit, if not in operation with the major unit, shall be so designed as to be turned on automatically without interruption of service and shall be located at or near the major unit in order to avoid confusion of the pilot due to sudden and unexpected change of location of the light source.

In case the landing area exceeds the size required for a Class "1" rating at the altitude in question, the area to be floodlighted in the manner hereinabove specified shall at least meet the size requirements for a Class "1" rating but need not exceed them. It is highly desirable, however, that the entire landing area be lighted.

(h) All-night operation of lighting equipment.—The airport beacon, wind-direction indicator lights, boundary lights, obstruction lights, and roof marking lights shall be kept burning all night (from sunset until sunrise) every night. (It is preferable that this equipment be kept burning from one-half hour before sunset until one-half hour after sunrise).

(i) Night personnel.—Sufficient personnel shall be in attendance throughout the night for proper operation of the lighting equipment, for servicing aircraft, making minor repairs and giving weather service, and for operating the fire-fighting equipment.

"B" rating.—Airports receiving a "B" rating on night lighting equipment shall have the following:

(a) An airport beacon as required for an "A" rating.

(b) An illuminated wind-direction indicator as required for an "A" rating.

(c) Boundary lights as required for an "A" rating.

(d) Obstruction lights as required for an "A" rating.

(e) The exterior surface of one hangar floodlighted and the name of the city or town marked on a hangar roof, or other suitable area, and illuminated, all in the manner required for an "A" rating.

(f) A ceiling projector as required for an "A" rating.

(g) A landing area floodlight system, portable or otherwise, which will provide suitable illumination for safe landing of airplanes under ordinary conditions and which will give a minimum vertical plane intensity of illumination over the usable portion of the landing area, or a portion thereof equivalent to the area required for a "1" rating on size, of at least 0.035 foot-candle.

(h) All night operation of lighting equipment as required for an "A" rating.

(i) Sufficient personnel in attendance throughout the night for proper operation of the lighting equipment, servicing aircraft, giving weather service, and operating fire-fighting equipment.

"C" rating.—Airports receiving a "C" rating on night lighting equipment shall have the following:

(a) An airport beacon as required for an "A" rating.

(b) An illuminated wind-direction indicator as required for an "A" rating, except that said wind-direction indicator shall be equivalent in effect to at least the wind-direction indicator required for a "C" rating on general equipment and facilities.

(c) Boundary lights as required for an "A" rating.

(d) Obstruction lights as required for an "A" rating.

(e) A ceiling projector as required for an "A" rating.

(f) The name of the city or town marked on a hangar roof, or other suitable area, and illuminated as required for an "A" rating.

(g) All-night operation of lighting equipment as required for an "A" rating.

(h) Attendance available on request.

"D" rating.—Airports not possessing sufficient night lighting equipment to receive a "C" rating but which possess either an airport beacon or boundary light system, or both, together with an illuminated wind-direction indicator and adequate obstruction lights, will be given a rating of "D", providing all such lighting equipment is kept burning all night every night.

"E" rating.—Airports having the necessary night lighting equipment to meet the requirements of any of the above ratings and which keep this equipment available for operation on request, but which do not give the all-night operation required for these ratings, will be given the rating of "E" on night lighting equipment.

"X" Rating: The rating of "X" will be given to airports having no night-lighting equipment, or which do not provide all-night operation of lighting equipment or which do not keep this equipment available for operation on request as hereinabove required.

PART III. RATING OF AIRPORTS FOR SEAPLANES

BASIC REQUIREMENTS

SECTION 8. The minimum basic requirements for the rating of seaplane airports are as follows: The seaplane airport shall be situated on or directly connected with a body of water having a minimum depth of not less than 6 feet at any time, calm enough for operations in all ordinary weather, and sufficiently large to permit landing and taking off of seaplanes and flying boats without hazard. By direct connection is meant a canal or other stream of water wide enough to allow taxiing of planes without difficulty and a distance of not over one-quarter of a mile from the actual airport to the open water.

The airport shall be situated on a good road leading to the nearest city or town. It shall be equipped with an approved type of wind-direction indicator, as hereinabove specified, and shall be marked either on hangar roof, or other suitable area, or on land immediately adjacent to the water with the name of the city or town in the manner required under Section 4 (e).

The airport shall be provided with facilities of supplying aircraft with fuel, oil, and water; also drinking water shall be available. If there are no rest rooms on the airport a suitable latrine shall be provided. The airport shall have dependable communication and transportation facilities to the nearest city or town. Airport personnel shall be in attendance by day or available on call by telephone at the airport. In the latter case, a directory and full instructions for reaching such personnel shall be available in the telephone booth or receptacle.

RATING ON GENERAL EQUIPMENT AND FACILITIES

SECTION 9. "A" rating.—In addition to the facilities named in the basic requirements, seaplane airports rated "A" on general equipment shall have the following:

(a) At least one hangar measuring not less than 80 feet by 120 feet in the clear inside with doors open, with 22-foot overhead clearance, with full-width door opening in either one or both ends or one or both sides, and with safe provision for heating water and oil. In localities where freezing temperatures are experienced the hangar shall be heated sufficiently to prevent freezing of water.

(b) Wind-direction indicator as required for an "A" rating for landplane airports.

(c) Day marking of telephone and transmission line poles and similar obstructions in the immediate vicinty of the landing area as required for an "A" rating for landplane airports.

(d) Repair equipment sufficient to permit changing engines, pontoons, and amphibian landing gear in addition to equipment for major engine, plane, and hull repairs.

(e) Means for hauling planes out of the water. This will require either a marine railway or a suitable ramp. Dollies, cradles, or other apparatus suitable for carrying seaplanes and flying boats from the water into the hangar will be necessary, as well as power for hauling out cradles when loaded, such as a small tractor, a motor-truck, or a winch.

(f) A boat capable of at least 10 knots speed for towing disabled planes to the airport and for use as a tender and rescue boat.

(g) Weather instruments as required for an "A" rating for landplane airports.

(h) Radio-receiving set and loud-speaker, under certain conditions, as required for an "A" rating for landplane airports.

(i) First-aid equipment as required for an "A" rating for landplane airports.

(j) Register as required for an "A" rating for landplane airports.

(k) Mooring facilities properly placed offshore for flying boats or seaplanes.

(l) Adequate fire-fighting apparatus as required for an "A" rating for landplane airports.

(m) Airport personnel as required for an "A" rating for landplane airports.

(n) Sleeping quarters for at least three men, in addition to station personnel, as required for an "A" rating for landplane airports.

(o) Waiting and rest rooms at or near the hangar.

(p) Restaurant or other source of food supply as required for an "A" rating for landplane airports.

"B" rating.—In addition to the facilities named in the basic requirements, seaplane airports rated "B" on general equipment shall have the following:

(a) At least one hangar measuring not less than 80 feet by 100 feet in the clear inside with doors open, with 18-foot overhead clearance, with full-width door opening in either one or both ends or one or both sides, and with safe provisions for heating water and oil.

(b) Wind-direction indicator as required for an "A" rating for landplane airports.

(c) Day marking of telephone and transmission line poles and similar obstructions in the immediate vicinity of the landing area as required for an "A" rating for landplane airports.

(d) Repair equipment sufficient to permit changing engines and pontoons and amphibian landing gear, in addition to equipment for minor engine, plane, and hull repairs.

(e) Means for hauling planes out of the water such as required for an "A" rating for seaplane airports.

(f) A boat capable of at least 8 knots speed to act as tender, rescue boat, etc.

(g) Weather instruments as required for an "A" rating for landplane airports.

(h) First-aid equipment as required for an "A" rating for landplane airports.

(i) Register as required for an "A" rating for landplane airports.

(j) Mooring facilities as required for an "A" rating for seaplane airports.

(k) Adequate fire-fighting apparatus as required for an "A" rating for landplane airports.

(l) Airport personnel as required for a "B" rating for landplane airports.

(m) Sleeping quarters for at least two men, in addition to station personnel, as required for a "B" rating for landplane airports.

(n) Rest room at or near hangar.

"C" rating.—In addition to the facilities named in the basic requirements, seaplane airports rated "C" on general equipment shall have the following:

(a) At least one hangar measuring not less than 50 feet by 60 feet in the clear inside with doors open, with 16-foot overhead clearance and with full-width door opening in either one or both ends or one or both sides, and with safe provisions for heating water and oil.

(b) Wind-direction indicator as required for a "C" rating for landplane airports.

(c) Suitable means for hauling planes out of the water, such as required for an "A" rating for seaplane airports.

(d) A boat capable of at least 8 knots speed for use as a tender, rescue boat, etc.

(e) First-aid equipment, fire-fighting equipment, and register as required for an "A" rating for landplane airports. (The day marking of telephone and transmission lines and similar obstructions in the immediate vicinity of the landing area as required for the "A" and "B" ratings is not required for either "C" or "D" ratings, but is urgently recommended).

(f) Rest rooms.

"D" rating.—Seaplane airports which do not possess sufficient general equipment to obtain A, B, or C ratings, but which meet the basic requirements, will receive a rating of "D" on general equipment and facilities.

RATING ON SIZE OF EFFECTIVE LANDING AREA

SECTION 10. No seaplane airports will be rated unless they permit an unobstructed climb after taking off. The existence of reefs, shoals, sandbars, etc., within the areas described hereafter as "1," "2," "3," or "4" will eliminate consideration for rating unless, in the opinion of the Department of Commerce, marking and lighting of these dangerous obstructions eliminate all hazard. Such markers will, of course, have to conform to local and Federal harbor or river regulations both for day markers and night lights.

"1" rating.—In addition to the basic requirements, seaplane airports receiving "1" rating on size of effective landing area shall have clear approaches and be large enough to permit at least a 4,000-foot effective run in all directions.

"2" rating.—In addition to the basic requirements, seaplane airports receiving a "2" rating on size of effective landing area shall have clear approaches and shall be large enough to permit at least a 3,500-foot effective run in all directions or shall have two landing courses, one aligned with the general direction of the prevailing wind, with clear approaches and permitting at least four-way landing, the landing courses to be at least 600 feet wide and not less than 4,000 feet in effective length and not to cross or converge at an angle of less than 60°.

"3" rating.—In addition to the basic requirements, seaplane airports receiving a "3" rating on size of effective landing area shall have clear approaches and shall be large enough to permit at least a 3,000-foot effective run in all directions, or shall have two landing courses, one aligned with the general direction of the prevailing wind, with clear approaches and permitting at least four-way landing, the landing courses to be at least 600 feet wide and not less than 3,500 feet in effective length and not to cross or converge at an angle of less than 60°.

"4" rating.—A seaplane airport which meets the basic requirements but which is not large enough to receive a "3" rating on size of landing area will be rated as "4" if, in the opinion of the Secretary of Commerce, it provides sufficient area for the use to which it is being put.

"O" rating.—A seaplane airport which, in the opinion of the Secretary of Commerce, is unsafe for operation, but from which operations are nevertheless taking place and which requests a rating, will be rated "O" on size of effective landing area.

RATING ON NIGHT LIGHTING EQUIPMENT

SECTION 11. The matter of lighting seaplane airports is one to be treated as a separate problem in every case, as the possibility of interference with river, ocean, or harbor traffic makes general rules impossible. Floodlighting of the landing area is usually necessary, although the installation of boundary lights is ordinarily impracticable. Obstruction lights may be placed on obstacles if such lights do not conflict with local or Federal navigation laws and regulations. Lighting plans for seaplane airports shall be referred to the Department of Commerce, Washington, D. C., which department will determine whether there is any conflict between the proposed lighting system and the existing navigational aids for water craft, and whether the proposed system meets the special requirements for night lighting of such airports.

Subject to the foregoing statement, the requirements for the rating of seaplane airports on night lighting equipment are as follows:

"A" rating.—Seaplane airports receiving an "A" rating on night lighting equipment shall have the following:

(a) An airport beacon as required for an "A" rating for landplane airports.

(b) An illuminated wind-direction indicator as required for an "A" rating for landplane airports.

(c) Suitable boundary lights (when practicable).

(d) Suitable obstruction lights.

(e) The exterior surface of hangars floodlighted and the name of the city or town marked on a hangar roof, or other suitable surface, and illuminated, all as required for an "A" rating for landplane airports.

(f) Ceiling projector as required for an "A" rating for landplane airports.

(g) Landing area floodlight system as required for an "A" rating for landplane airports.

(h) All-night operation of lighting equipment as required for an "A" rating for landplane airports.

(i) Night personnel as required for an "A" rating for landplane airports.

"B" rating.—Seaplane airports receiving a "B" rating on night lighting equipment shall have the following:

(a) An airport beacon as required for an "A" rating for landplane airports.

(b) An illuminated wind-direction indicator as required for an "A" rating for landplane airports.

(c) Suitable boundary lights (when practicable).

(d) Suitable obstruction lights.

(e) The exterior surface of one hangar floodlighted and the name of the city or town marked on a hangar roof, or other suitable surface, and illuminated, all as required for an "A" rating for landplane airports.

(f) A ceiling projector as required for an "A" rating for landplane airports.

(g) A landing area floodlight system as required for a "B" rating for landplane airports.

(h) All-night operation of lighting equipment as required for an "A" rating for landplane airports.

(i) Night personnel as required for a "B" rating for landplane airports.

"C" rating.—Seaplane airports receiving a "C" rating on night lighting equipment shall have the following:

(a) An airport beacon as required for an "A" rating for landplane airports.

(b) An illuminated wind-direction indicator as required for a "C" rating for landplane airports.

(c) Suitable boundary lights (when practicable).

(d) Suitable obstruction lights.

(e) Ceiling projector as required for an "A" rating for landplane airports.

(f) The name of the city or town marked on a hangar roof, or other suitable surface, and illuminated as required for an "A" rating for landplane airports.

(g) All-night operation of lighting equipment as required for an "A" rating for landplane airports.

(h) Attendance available on request.

"D" Rating—Seaplane airports not possessing sufficient night lighting equipment to receive a "C" rating but which possess either an airport beacon or boundary light system, or both, together with an illuminated wind-indicator and suitable obstruction lights, will be given a rating of "D," providing all such lighting equipment is kept burning all night every night.

"E" Rating—Airports having the necessary night lighting equipment to meet the requirements of any of the above ratings and which keep this equipment available for operation on request, but which do not give the all-night operation required for these ratings, will be given the rating of "E" on night lighting equipment.

"X" Rating—The rating of "X" will be given all seaplane airports having no night lighting equipment, or which do not provide all-night operation of lighting equipment or which do not keep this equipment available for operation on request as hereinabove required.

PART IV. RATING ON COMBINED LANDPLANE AND SEAPLANE AIRPORTS

SECTION 12. Airports offering facilities for the operation of both landplanes and seaplanes will be given two separate and distinct ratings,—first, as an airport for landplanes and second, as an airport for seaplanes.

Appendix 10—*Intermediate Landing Field Rules of the U. S. Department of Commerce.*

The following rules have been promulgated by the Department of Commerce to cover the use of the Department's Intermediate Fields.

1. All Aircraft Pilots and the Aeronautical Public must comply with the Air Commerce Regulations and Landing Field Rules promulgated by the Department of Commerce.

2. Intermediate Landing Fields are established under the authority of the Air Commerce Act to provide for safety of the aeronautical public in cases of emergencies and no exclusive rights, perferential privileges, or commercialization of any emergency field will be permitted and the landing field shall not be used in any manner inconsistent with the Air Commerce Act.

3. A landing plane has the right of way over planes moving on the ground or taking off.

4. Upon landing, the airplane shall be taxied off the landing area to a location that will not interfere with or become a hazard to an airplane that may find it necessary to make an emergency landing without warning.

5. The take-off or taxiing shall not be commenced until there is no risk of collision with landing aircraft and until preceding aircraft are clear of the field.

6. No airplane shall be taxied faster than 15 miles per hour.

7. No airplane will be fueled while the engine is running.

8. Blocks should always be placed in front of the wheels before starting the engine.

9. All blocks shall be equipped with ropes or some suitable means of pulling blocks.

10. No engine shall be started or run unless the pilot or other competent person shall be in the cockpit attending the controls.

11. In starting an aircraft engine, the customary procedure will be used by the person operating the starting device and the person at the engine controls. All challenges or signals between the former and the latter shall be clearly understood before action is taken by either.

12. Landings and take-offs shall be made, when practicable, into the wind. An aircraft shall not follow in the wake of another aircraft which preceded it in taking off until such aircraft has gained a safe distance.

13. Aircraft shall not take off over dwellings, obstructions or parked cars unless unavoidable.

14. On test flight of aircraft subsequent to a forced landing, the personnel making such flights will be limited to the number necessary to properly perform the required test.

15. All persons using an intermediate landing field shall exercise due care to guard against fire and injury to persons or property. No rubbish or material shall be left on any portion of the intermediate field and all debris shall be cleaned up by the visiting pilot or crew.

16. Unhoused aircraft must be parked in the space allotted and shall be properly secured by ropes and stakes, or otherwise, when left unattended over night or during weather conditions which indicate the necessity for it, and shall be properly lighted to prevent collision by other aircraft.

17. Caretakers shall render accident reports to the Department of Commerce for all accidents occurring on their field.

18. All visiting pilots landing on this field are required to report immediately to the caretaker to register their names, addresses, type of equipment license or military number of aircraft, its ownership, the time of their arrival, expected time of departure, service required, and such other information as may properly be required for record purposes.

19. The landing field shall be kept in proper condition for emergency landings at any and all times. If not in proper condition, the boundary lights shall be turned off at night and a red flag flown from the beacon tower by day. In addition, the caretaker shall report the facts to the District Superintendent of Lighthouses, so that notices to the Aeronautical Public may be issued in the publications of the Department of Commerce.

20. Caretakers shall immediately report unsafe or hazardous landing conditions at an intermediate field to the nearest airport or Airways Control Station for the purpose of advising pilots, and when the landing field is restored to a safe condition the proper authorities shall be promptly notified.

21. Pilots forced to make emergency landing at an intermediate field, due to stress of weather, mechanical, or other difficulty, are authorized to request the caretaker to report their arrival to the nearest Airways Control Station by telephone, reversing the toll charges.

22. Telephones at intermediate fields are available to the pilot, crew

or passengers of airplanes making an emergency landing, upon payment of the telephone toll charge to the caretaker, who will account for the calls.

23. Pilots of airplanes landing at an intermediate landing field due to stress of weather are authorized to request the Airways Control Station to furnish weather information and the Control Station shall furnish weather information once each hour by radio broadcast or by telephone until the airplane departs.

24. The caretaker shall report to the nearest control station the departure of an airplane that has landed at an intermediate field due to stress of weather or mechanical or other difficulty, giving the number of the airplane, the name of pilot, the number of passengers, the time of departure, and the destination.

25. The airway beacon and boundary lighting system shall be operated from sunset to sunrise.

26. In cases of emergency landing at an intermediate field, the caretaker will promptly and courteously render all possible assistance to the airplane, pilot, crew, and passengers, and assist the pilot in preparations to take off. Caretakers are permitted to receive reasonable and just remuneration for extraordinary services rendered, including transportation.

27. A limited supply of aviation gasoline will be stored by the Government at intermediate landing fields for sale in cases of emergency at a price fixed by the District Superintendent, in excess of its market value to cover losses due to handling and transportation. The caretaker will receive cash for all sales and make proper return in accordance with Regulations therefor.

28. No fixed base operator will be permitted to establish at or operate from an intermediate landing field. The regular use of an intermediate landing field for embarkation or landing of passengers, exchange of mails or loading and discharging of cargo or any other commercial operation is prohibited.

29. The use of an intermediate field for aeronautical activity of a public character may be authorized by the Assistant Secretary of Commerce for Aeronautics upon application accompanied by and subject to the consent and conditions laid down by the owner of the property. The use of the field for purposes inconsistent with the rights and privileges covered by the Intermediate Landing Field license is prohibited. Grazing of stock, parking of cars or airplanes, storage of any equipment or material or leaving any debris on the field, in any manner that may cause an accident, is prohibited.

30. Any person who, with intent to interfere with air aviation in the navigable airspace, exhibits within the United States any false light or signal at such place or in such manner that it is likely to be mistaken for a true light or signal in connection with an intermediate landing field or other air navigation aid, or, who knowingly removes, extinguishes or interferes with the operation of any such true light or signal, shall be guilty of an offense punishable by a fine not exceeding $5,000 or by imprisonment not exceeding five years, or both such fine and imprisonment.

31. It is hereby made the duty of every licensed pilot or mechanic to carry out these rules and also to see that the general public uses due care and caution to prevent injury to themselves and other persons or property and, further, preserve and protect the property and equipment of whatever nature on the field.

Appendix 11—*Requirements for Private Beacons Issued by the U. S. Department of Commerce.*

EFFECTIVE January 1, 1929, all private aeronautic lights heretofore approved must be equipped with a fixed projector of intense candlepower showing a narrow shaft of light pointed in the direction of the nearest landing field.

The Air Commerce Regulations provide for the certification of privately established aeronautic lights serving as aids on established civil airways, marking landing fields or landmarks leading to a safe, lighted landing field and it is the purpose of the Department of Commerce to encourage the establishment of private Air Navigation Facilities that serve as true aeronautical lights.

Private aeronautic lights located on civil airways will be certified if of distinctive characteristic and of equal effectiveness to the Department's beacons. If the private light is a rotating beacon, it should run at 6 R. P. M. and be inclined approximately one degree above the horizon, having the same general characteristics as the rotating beacons established on the national airways.

Private aeronautic lights in cities not on these airways will be certified only if they have characteristics differing from those of aeronautic lights established on national airways or on landing fields, and serve as landmarks from which a departure can be taken to reach a safe, lighted landing field. The characteristics must be such as to preclude the possibility of confusion with lights marking this landing field.

In addition to the above requirements all rotating beacon lights must be equipped with a fixed projector, throwing a narrow pencil of light for two or three miles in the direction of the nearest landing field. This projector must be at least 24 inches in diameter and furnished with a parabolic reflector giving a high candlepower beam of not over 3 degrees spread, and equipped with a 32-volt, 600-watt light source. The beam should be elevated sufficiently to clear intervening structures. Aeronautic lights must necessarily be reliable in operation between sunset and sunrise.

The establishment and certification of a private aeronautic light in one locality will preclude certification of a light of similar type within a distance which might cause uncertainty in its identification when picked up by air pilots in foggy weather. The certification of a private aeronautic light by the Department obligates the operator of such a light to immediately advise the Airways Division by wire of any suspension or failure in the operation of the light, the probable period of such suspension and the date on which the light is returned to service.

All privately operated rotating beacon lights, established for advertising purposes which are not certified by the Department of Commerce as aeronautical aids, and which may be the subject of complaints by the air pilots, owing to the fact that they are confusing with true lights, will be branded as false lights under the Air Commerce Act of 1926 and, as such false lights, will be ordered discontinued under the penalty—$5,000 fine and 5 years' imprisonment—provided for by law.

Application for the establishment of private aeronautic lights shall be made to the Commissioner of Lighthouses on Department of Commerce forms 117-B, "Application for Certification, Rating or Discontinuance of Aeronautical Light," together with a sketch or map showing location of proposed light with reference to the nearest landing field. The purpose served by the light and the aid rendered to the air pilot shall be fully established and substantiated. Private aeronautic lights will be listed for the information and guidance of pilots by the Department of Commerce in its bulletins.

Appendix 12—Rules, Regulations, Rates and Charges Applying at Oakland (Calif.) Municipal Airport.

FIELD RULES

I. ADMINISTRATION

1 All visiting pilots landing on the Oakland Municipal Airport field are required to report immediately to the Administration Office to register their names, addresses, type of equipment, license or military number of aircraft, its ownership, the time of their arrival, expected time of departure, service required, and such other information as may be properly required for record purposes.

2. Immediately prior to his departure, each visiting pilot shall report to the Administration Office and check out.

3. The airport or flying field shall be open to render service from daylight to dark.

4. Lighting of the port for night flying shall be done only to meet the requirements of the United States Department of Commerce and the Air Mail Service. If additional night lighting or other service is desired, the Administration Office should be duly notified.

5. It is hereby made the duty of every pilot, mechanic or other person employed or stationed upon the airport to cooperate with the authorities in enforcing these rules and in aiding the general public to use due care and caution to prevent injury to themselves and other persons or property, and to preserve and protect property and equipment of whatever nature on the field. All persons instructing student pilots in aviation shall carefully acquaint such students with the rules and regulations established from time to time by the public authorities, and shall be responsible for their conduct while under their direction.

6. It shall be the duty of every person participating in or witnessing any accident happening on or near the airport to make promptly a full report thereof to the Administration Office, together with the names and addresses of all available witnesses.

7. The conduct and management of the public in attendance at the airport shall be at all times under the control of the Field Superintendent.

8. All pilots, mechanics, student pilots and other persons stationed or employed upon the airport shall register at the Administration Office in order that a directory may be kept of their names, addresses and telephone numbers, together with the nature of their business or occupation.

II. TAKING OFF AND LANDING

1. All planes, except the mail and passenger planes engaged in regular service for which the siren may be sounded, shall upon landing on the airport and before turning into the line, come to a full stop with the

motor running, and shall not proceed again until the pilot has assured himself that there is no danger of collision with other aircraft approaching across his path or from the right. In landing, all planes shall keep a distance of three hundred feet from other aircraft.

2. Pilots shall land and take-off as far from the hangars or the parking space of aircraft as it is practicable.

3. All aircraft in taking off shall maintain a straight course into the wind until clear of the field boundaries. All approaches to the field shall be made from the leeward side in a direct course of at least one thousand (1,000) feet. No nose-down spiral landing upon the field shall be permitted except when required in examination flight tests by the authorities of the United States Department of Commerce. All turnings on or over the airport under an altitude of one thousand (1,000) feet shall be to the right.

4. Aircraft shall not take off over hangars, buildings, the automobile parking areas, or other obstructions unless strictly unavoidable.

5. No aircraft shall be flown at any time nearer than one hundred (100) feet above any of the public streets surrounding the airport. In landing and taking off, particular care must be taken to secure the required clearance of one hundred (100) feet.

6. Blocks which shall be provided by the field authorities shall always be placed in front of the wheels before starting engine. Such blocks shall be equipped with ropes or other suitable means of pulling blocks.

7. Upon sighting of any approaching aircraft carrying the United States Mail, or operating in connection with any regular schedule passenger line, such planes should be given right of way on landings and take-offs.

8. The following signals from the siren must be strictly observed:

(a) One (1) long blast of siren—All planes shall remain intact until the mail and/or passenger planes shall clear the field on taking off or landing.

(b) Two (2) short blasts of siren—All flying operations may resume.

(c) Repeated long blasts of siren (about fifteen seconds' duration)—Fire alarm.

III. TAXIING

1. No aircraft shall be taxied into or out of hangars or over the cement aprons.

2. All aircraft shall be taxied at a slow and reasonable speed, and in any event not over eight (8) miles per hour in the vicinity of hangars or other structures and in leaving hangar aprons taxiing to and from line. A person should be on each wing whenever possible.

3. All aircraft shall be moved or taxied from the aprons to a designated or established line and shall remain stationed at such a line when not in hangars or under repair. Approaches to hangar aprons shall be clear at all times.

4. No aircraft shall remain on the rock runways longer than is absolutely necessary in flying operations. The rock runways shall be kept clear of obstructions to aircraft at all times. In inclement weather, when permission is given therefor by the field authority, the said runways may be used for the landing and taking off of aircraft.

IV. RUNNING ENGINES

1. At no time shall motors be tuned up so that the Administration Building, the hangars, shops or other buildings or any group of people in the restricted area shall come in the path of the propeller stream.

2. No motor shall be run in hangars.

3. No engine shall be fueled while the engine is running, or in hangars or other enclosed spaces.

4. No engine shall be started or run unless a competent pilot or competent mechanic shall be in the cockpit attending the controls.

5. In starting an aircraft engine, the customary procedure shall be used by the person operating the starting device and the person at the engine controls. All challenges or signals between the former and the latter shall be clearly understood before action is taken by either.

6. When engines are not running, the propellers of all aircraft must be in a horizontal position.

7. Aircraft shall be started and warmed up only in the places designated for such purposes by field authority.

V. USE OF FIELD

1. All persons using in any way the airport area shall exercise reasonable caution to guard against fire and injury to persons or property. No rubbish shall be scattered about the airport area. Operators overhauling or repairing aircraft shall be responsible for the space allotted to them.

2. On any test flight of aircraft the personnel making such flight shall be limited to the number necessary to properly perform the required test. At no time shall passengers be carried on such flights as ballast.

3. Unhousd aircraft must be parked in the space allotted therefor and shall be firmly secured to the ground by ropes and stakes, or otherwise, when left unattended over night or during weather conditions which indicate the necessity for it. Any aircraft left unattended shall be entirely at the risk of the owner or operator thereof.

4. Repairs to aircraft or motors shall be made in spaces designated or allotted by the field authority.

5. In the allotting of space in hangars, preference shall be given to aircraft which are being used in active flying service.

6. Student pilots when soloing shall display one white streamer on each rear outside strut of plane.

7. No person shall be allowed on the flying field or runways except upon business connected with the airport, or with permission of the Field Superintendent. No person shall be allowed in the public hangars after closing hours except when accompanied by one of the airport authorities.

8. No children under the age of eight years shall be allowed to fly from the airport unless accompanied by a parent, guardian or other responsible adult person.

9. No person shall drive an automobile or any other vehicle in excess of twenty (20) miles an hour upon any of the roads located upon the Oakland Municipal Airport.

VI. PENALTIES

1. Any person or persons operating or handling any aircraft and violating any of these rules, or refusing to comply therewith, may be promptly removed or ejected from the said airport by or under the authority of the Field Superintendent and, upon the order of the Port Manager or the Board of Port Commissioners, may be deprived of the further use of the airport and its facilities for such length of time as may be required to insure the safeguarding of the same and the public and its interests therein.

REGULATIONS

(Port Ordinance No. 20, As Amended)

AIRPORT A TERMINAL FACILITY

SECTION 1. The Oakland Municipal Airport is and shall be conducted and managed as a terminal facility of the harbor of the City of Oakland and for the promotion and accommodation of shipping, commerce and navigation.

APPLICATION OF PROVISIONS OF CITY ORDINANCE NO. 4045 N. S., AS AMENDED

SECTION 2. All the provisions and penalties of Ordinance No. 4045 N. S. of the Council of the City of Oakland, as amended by Ordinance No. 4152 N. S., regulating the flying of aircraft and the establishment and maintenance of flying fields, and all the provisions of the Air Commerce Regulations as established by the United States Department of Commerce (Aeronautics Branch) under the authority of the Air Commerce Act of 1926, referred to in said ordinance, are hereby adopted by reference, made a part hereof and declared applicable to the port area of the City of Oakland and particularly to the Oakland Municipal Airport and enforceable as law therein, as fully as if the same, and each and all of them were completely set forth herein.

PERMISSION TO USE AIRPORT

SECTION 3. No person shall use the said airport as the base or terminal for the carrying on of commercial aviation, or the carrying of passengers, freight or express, or for student flying, communications, or other commercial purpose or transportation without first securing the permission of the Board of Port Commissioners or its Port Manager, and paying the fees and charges prescribed for such privileges, the use of the airport, its facilities and for services rendered.

PERMISSION TO CARRY PASSENGERS

SECTION 4. No person shall carry passengers, for hire or award, from, to and over or about the Oakland Municipal Airport unless such person is using the airport as a permanent base, or shall have first secured permission from the Board or the Port Manager, and shall have paid in advance the fees and charges prescribed.

USE OF AIRCRAFT AND TOOLS BELONGING TO OTHER PARTIES

SECTION 5. No person shall take or use any aircraft, or any parts or tools thereof, owned, controlled or operated by any other person, while such aircraft, parts or tools are stored, housed or otherwise left on the said airport or within its hangars, without the written consent of the owner or operator thereof, or other satisfactory evidence duly presented to the Field Superintendent.

SMOKING AND STRIKING MATCHES PROHIBITED

SECTION 6. No prson shall engage in smoking, or strike any match inside of or within fifty (50) feet of any aircraft, or within fifty (50) feet of any containers of gasoline or other highly combustible liquids, or within any hangars (except offices thereof) or workshops located upon said airport.

USE OF INTOXICATING LIQUOR PROHIBITED

SECTION 7. No person shall take any aircraft from the field or hangars or operate the same while under the influence of or using or having personal possession of intoxicating liquor.

CARRYING OF INTOXICATING LIQUOR AND DRUGS PROHIBITED

SECTION 8. No person handling or operating any aircraft on or at the said airport shall carry or transport or in any manner dispense intoxicating liquor, cocaine or other habit-forming drugs.

PERSONS OPERATING UNDER LETTER OF AUTHORITY FROM SECRETARY OF COMMMERCE

SECTION 9. No person operating under a letter of authority from the Secretary of Commerce and not possessing a license as provided by the Air Commerce Regulations shall at any time operate any aircraft carrying passengers from, to or over the said airport, or operate any aircraft over the hangars, administration building, automobile parking areas, or any gatherings of the public, or nearer than five hundred (500) feet thereof, or nearer than one thousand (1,000) feet in the air from any automobiles or persons upon any public streets of the said airport.

RESPONSIBILITY OF PARTIES USING AIRPORT

SECTION 10. The permission granted by the said Board to use the said airport and its facilities, or to fly to, from or over the same, shall be at all times conditioned upon the assumption of full responsibility therefor by every person exercising or taking advantage of such permission. It shall be a further condition thereof that each person, as a consideration for the use of such airport and/or its facilities, shall at all times release, hold harmless and indemnify the City of Oakland, the Board of Port Commissioner and/or its agents and employees from any and all responsibility, liability, loss or damage resulting to any such person, or caused by or on his behalf and incident to the manner in which the airport is operated, constructed or maintained or served from within or used from without. The use of such airport by any person for any purpose, or the paying of any fees therefor, or the taking off or landing aircraft thereupon, shall be itself an acknowledgment that such person accepts such privileges on the conditions herein set forth.

ADOPTION OF FIELD RULES BY RESOLUTION

SECTION 11. In addition to the foregoing, the Board of Port Commissioners shall, by resolution, adopt from time to time such field rules or administrative regulations as may be required to safeguard and regulate the use of the Oakland Municipal Airport and protect the public interests therein. It shall be unlawful for any person in or about the said airport to violate any such field rules, and any person so violating such rules, or any of the provisions of this ordinance, or refusing to comply therewith may be deprived of the use of the said airport or its facilities or of any right to fly therefrom for such reasonable time as may be deemed necessary to protect the public and its interests.

DEFINITION OF TERM "PERSON" AS USED HEREIN

SECTION 12. The term "person" herein used shall be construed to include any person, firm, corporation or association, plural and singular.

SECTION 13. Port Ordinance No. 13, adopted August 1, 1927, is hereby repealed.

PENALTIES

Section 14. Every person who shall violate, disobey or refuse to comply with any of the provisions of this ordinance, or any of the provisions of law incorporated therein, shall, upon conviction, be punishable by fine and penalty, not exceeding five hundred dollars ($500.00), or by imprisonment in the prison of the City of Oakland for not more than six (6) months, or by both such fine and imprisonment.

REGULATIONS (Continued)

(City of Oakland Ordinance No. 4045 N. S., As Amended)

SECTION 1. It shall be unlawful for any airman, as defined by the Air Commerce Act of 1926 adopted by the Congress of the United States of America, or other person, to navigate or fly any aircraft over the area of the City of Oakland, or land any aircraft upon, or fly the same from any part of the city otherwise than in conformity with the air traffic rules and other provisions of the "Air Commerce Regulations," as established by the United States Department of Commerce (Aeronautics Branch) under the authority of the said Air Commerce Act.

SECTION 2. It shall be unlawful for any airman, or other person, to navigate any aircraft over, land upon, or take off from any part of the city, or serve as an airman in connection with any aircraft therein, unless such airman, or other person, possesses a proper certificate or license issued under authority of the Secretary of Commerce of the United States upon examination of such person as to his fitness, experience and other qualifications, or otherwise, as provided in the said Air Commerce Regulations.

SECTION 3. It shall be unlawful for any airman, or other person, to navigate any aircraft from, to, over or upon any part of the city, except aircraft which has been registered or licensed under authority of the Secretary of Commerce of the United States and rated as to air worthiness, in accordance with the provisions of the said Air Commerce Regulations. No registered but unlicensed aircraft shall be flown over or operated in any part of the city except on or within two miles of the Oakland Municipal Airport.

SECTION 4. Any non-resident unlicensed airman, or other non-resident person without lawful authority as herein provided, landing any aircraft in the city from any place beyond its boundaries, of any person flying any unlicensed aircraft into the city shall depart therefrom within twenty-four hours, provided, however, the Chief of Police may grant such person written permit to keep such aircraft grounded in said city for a longer period, provided such aircraft is not navigated in the meanwhile. Having once taken off from the ground, the return of any such aircraft to any part of the city (except on or within two miles of the municipal airport in case of registered planes) shall be deemed a violation of this ordinance.

SECTION 5. It shall be unlawful for any person to carry any passengers in any aircraft for hire or reward, unless such person possess a license as a "transport pilot" or as a "limited commercial pilot" in accordance with the said Air Commerce Regulations.

SECTION 6. For the purposes of this ordinance, the said Air Commerce Regulations of the United States Department of Commerce, effective June 1, 1928, and August 1, 1928, as published in Information Bulletin No. 7 of the Aeronautics Branch of said Department, a copy of which bulletin has been heretofore filed with the City Clerk, are hereby adopted by reference and made a part hereof as fully as if the same and each and all of them and every part thereof were completely set forth herein. (Amended June 14, 1928.)

SECTION 7. It shall be unlawful for any person to establish, conduct or maintain a flying field within the City of Oakland, or enlarge or alter the boundaries of the same, or erect any structures thereupon, without first placing the field in safe and proper condition for the purposes intended, paying the license fees herein provided, and obtaining a permit therefor in writing from the City Council.

SECTION 8. In making application for such permit, the applicant must specify in writing the location of the proposed field, its size and character, the number and type of aircraft to be used, the location and size of any buildings thereon, name and address of the owner, the name of the person to be in charge of the premises, the purpose for which the premises were formerly used, the intended purpose for which it is to be put, and the manner in which the business is to be maintained.

SECTION 9. When application is made, the Council shall immediately refer the same to the Chief of Police and the Superintendent of the Oakland Municipal Airport. Such officers shall investigate the proposed field and report to the Council, specifying the conditions, if any, necessary to be embodied in any permit.

SECTION 10. The Chief of Police shall also cause to be posted conspicuously on the premises a notice to the effect that application has been made for the permit and setting forth the time of hearing thereof before the Council, which hearing shall be not less than five (5) days after the date of such posting.

SECTION 11. In granting or refusing such permit, and in specifying the conditions, if any, upon which it may be granted, the Council shall consider the facts and circumstances stated or referred to in the application, the reports of the investigation officers and other pertinent facts which may concern the safety, health and general welfare of the public, and shall exercise a reasonable and sound discretion in the premises. Said permit shall be non-transferable.

SECTION 12. Every person establishing, conducting, or maintaining any flying field as herein provided shall pay a license fee in the amount of $50.00 per quarter, said fee to be payable in advance to the Treasurer of the City of Oakland. Said license shall be non-transferable.

SECTION 13. For failure to comply with any ordinance of the city, or when the public safety, health or general welfare shall require, or for other cause, the Council shall have power to revoke any permit previously granted, upon five days' notice of an order to show cause, mailed by the City Clerk to the holder of such permit, and posted upon the premises as provided in Section 10, and after a hearing thereon at a regular meeting of said Council. In revoking any such permit, the Council must exercise a like discretion as in granting or refusing permits.

SECTION 14. A "flying field" is any field or place from or to which aeroplanes or other aircraft are flown, or where aviation activities are carried on in the air for the purpose of selling and demonstrating aircraft, for schools of instruction, for the carrying of goods, merchandise or passengers for hire or reward or for other public purposes.

SECTION 15. The word "person" shall be understood to include any person, firm, corporation, association, society or club.

SECTION 16. Officers and members of the United States Army and Navy, or the Marine Corps, and officials of the United States, while actively engaged in the operation of aircraft in the service of the Government shall not be subject to the provisions of this ordinance.

SECTION 17. Nothing in this ordinance shall be construed to apply to, or interfere with, the conduct or management of the Oakland Municipal Airport, or the flying, operation or supervision of aircraft in connection therewith. So far as applicable, the provisions of this ordinance shall be deemed to be in addition to any rules and regulations provided for the use of such airport by the Board of Port Commissioners of the City of Oakland. Where a flying field is proposed to be located in the port area of the city, application therefor must be made exclusively to said Board, and its approval secured in the manner herein provided for the securements of permits from the City Council.

SECTION 18. Any violation of this ordinance, or any of the provisions incorporated herein, shall be deemed a misdemeanor, and the penalty shall be a fine not exceeding five hundred dollars ($500.00), or imprisonment in the city prison for not more than six (6) months, or both such fine and imprisonment. Every day's continuation of a violation of any of the provisions of this ordinance shall be deemed a separate and distinct offense.

SECTION 19. This ordinance shall take effect immediately (Effective December 6, 1927.)

RATES AND CHARGES

(Port Ordinance No. 31)

SECTION 1. The following charges, tolls and rates for services rendered by the Port Department at the Oakland Municipal Airport and for the use of the said air terminal of the Port of Oakland and its facilities are hereby adopted:

Item 1. **Storage.** Including use of field for taking off and landing.

A. Hangar	**Monthly**	**Daily**
Less than 1,000 sq. ft.	$40.00	$2.00
1,000 sq. ft. to 1,500 sq. ft.	50.00	2.50
1,500 sq. ft. to 2,000 sq. ft.	60.00	3.00
2,000 sq. ft. to 2,500 sq. ft.	70.00	3.50
Over 2,500 sq. ft.	75.00	4.00
B. Ground	20.00	
Ground rental over night		1.00

Item 2. **Commercial.** Including privilege of carrying passengers for hire or award, the chartering of aircraft for special trips, the training of students, demonstrating and sale of aircraft, and/or the use of the airport or its facilities for other commercial purposes. (These charges are in addition to those provided for in Item 1.)

	Monthly		**Daily**	
	Summer Rates	**Winter Rates**	**Summer Rates**	**Winter Rates**
Two-passenger plane	$45.00	$30.00	$25.00	$15.00
Four-passenger plane	60.00	45.00	32.50	22.50
Six-Passenger plane	75.00	60.00	40.00	30.00
Over six-passenger plane	90.00	70.00	52.50	37.50

NOTE: Summer rates shall apply during the months of April to November, inclusive. Winter rates shall apply from December to March, inclusive.

Item 3. **Mechanician Service.**

During regular working hours, per hour	$2.00
During other than regular working hours, per hour	$3.00

Item 4. **Washing Planes.**

Hostler service, per hour	$1.25

Item 5. **Fuel and Oil.** Fuel and oil for planes will be supplied by commercial oil companies who maintain and operate stations, with underground outlets on the field.

Item 6. **Lighting of Field and Hangars.**

Use of small flood lights, including turning on of lights, per hour or fraction thereof	$2.00
Use of B.B.T. flood light, including turning on of light, per hour or fraction thereof	3.00
Lighting of hangars, per hour	.25

Item 7, **Miscellaneous.**

Locker rental, per locker per month	$ 1.00
Tool box rental, per box per month	1.00
Bunks, per month or fraction thereof, per bunk	15.00
Bunks, per night, per bunk	1.00

Item 8. **Local Flights.** All persons using the airport for carrying of passengers for hire or award where landings are not made at other air terminals or flying fields shall at all times, in consideration of the right to use the field, abide by and charge at least the minimum rates customarily in force at the airport and hereby prescribed as standard by the Board of Port Commissioners, as follows:

For single passenger, ten-minute flights	$3.00
For carrying two or more passengers for ten minutes, each	2.50
For flights exceeding twenty minutes, per passenger	5.00

SECTION 2. Unless otherwise specified, all the rates prescribed in the foregoing schedule are per plane. Daily rates are per day or fraction thereof. Monthly rates are per month or fraction thereof, except that storage charges may be assessed for the last half of a month at one-half of the monthly rates.

SECTION 3. Storage, commercial and rental charges must be paid strictly in advance. Mechanician and other services must be paid for upon the completion of the work. All fees for planes in transit must be paid in cash.

SECTION 4. Air transport companies who may operate passenger or other air lines on regular schedule between the City of Oakland and other cities shall be subject to the foregoing rates and charges, provided the Board of Port Commissioners may enter into special agreements with any such company for the use of the airport and its facilities.

SECTION 5. Whenever, in any specific instance, it may be deemed proper or expedient, the Board, or the Port Manager by a writing, may authorize a temporary deviation from the rates, charges or tolls herein provided for.

SECTION 6. In addition to the right to bring an action in any court of competent jurisdiction, as provided by law, for the collection of any rates, tolls or charges provided for herein, the City of Oakland shall have and exercise a lien to enforce payment for all charges, fees and tolls for storage, rental, commercial privileges and other services rendered on, for or on account of any aircraft or other property landing upon or stationed at or upon the said airport. Such lien shall be of the character and enforced in the manner provided by the Civil Code of California. No person shall remove any aircraft or other property held under any such lien unless written authority be given therefor to such person by the Field Superintendent of the airport.

SECTION 7. Any person violating any of the provisions of this ordinance shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punishable by a fine of not more than five hundred dollars ($500.00) or by imprisonment in the city prison for a period of not more than six (6) months, or by both such fine and imprisonment. All the remedies herein provided for shall be cumulative.

SECTION 8. The term "item" as used herein shall be understood as being synonymous with the term "section." The term "person" shall be construed to include any person, firm, corporation, or association, plural or singular.

BIOGRAPHIES OF COLLABORATORS

Civil Airports and Airways

Frederick W. Lewis was educated at Cornell and has been engaged for the past 12 years in the building of golf courses, landscaping of large country estates and similar work related to the preparation of soil, its grading and turf development. He is Vice-President of the Lewis Development Company, Inc., and is also interested in the Lewis & Valentine Golf Course Co., Inc.

George E. Martin graduated from Purdue University in 1909 with the degree of B. S. in Civil Engineering. Since that time he has been constantly engaged in highway engineering and from 1914 to 1920 was in charge of the Highway Engineering Department of Purdue University. During the World War he served as Captain, 23rd Engineers, U. S. A. Mr. Martin is at present acting in an advisory capacity on highway engineering for the Barrett Company. He has given much of his attention to highway construction and drainage.

John S. Crandell has been engaged in highway engineering for many years and is Professor of Highway Engineering in the Department of Civil Engineering, University of Illinois.

John C. Worthington, airport engineer, was born in Dedham, Mass., in 1899 and graduated from Kent School in 1917. During the War he served in the Marine Corps and upon release from this service entered the oil business in Mexico and South America. He became interested in aviation in 1923 and later learned to fly. For the past few years he has been giving most of his attention to the design and construction of airports and has been associated with various airport firms. At present, he has charge of airport engineering for Black & Bigelow, Inc.

John E. Whitbeck was educated in mechanical and marine engineering and was connected with the Navy and Army Air Services from 1910 to 1919. From 1920 to 1926 he was Superintendent of the Eastern Division of the U. S. P. O. Air Mail Service in which capacity he had complete responsibility of all operations and maintenance of the New York-Chicago Division. Mr. Whitbeck is now President of Hadley Corporation, operators of the Hadley Airport, New Brunswick, N. J., and is also on the staff of Pan-American Airways, Inc., and has had charge of the installation of airports for this latter company. He is the author of many articles on aviation and has presented numerous technical papers on airport construction and equipment. Mr. Whitbeck is a recognized authority on aircraft and maintenance.

Charles B. Kirkham is one of the pioneers of aviation, having been identified with it since the earliest days. About 1910 he built the Kirkham concentric valve engines and since that time he has been responsible for an extensive list of other models. For several years he was connected with the engine development work of the Curtiss Aeroplane & Motor Company and was responsible for design of many of the well known engines produced by this company during and after the World War. Several years ago Mr. Kirkham left the Curtiss Company to establish his own business and he is now engaged in the manufacture of airplane and engine parts. For some years he also conducted a business in overhauling and rebuilding engines and airplanes and this very well-rounded experience makes him particularly fitted to comment on shop equipment for these purposes.

George W. Booth graduated from the Civil Engineering Department of Worcester Polytechnic Institute in 1891. For about 13 years he was engaged on water-works surveys and construction and in 1904 joined the engineering staff of the National Board of Fire Underwriters and since 1909 has been chief engineer of the Board. Mr. Booth is considered one of the foremost authorities on fire protection and in this capacity he has had constant contact with airport fire hazards and fire protection.

Walter Hinton is best known as the pilot of the U. S. Navy seaplane NC-4 in its trans-Atlantic flight of 1919. Since that time he has taken part in other epoch-making flights including the exploration of the upper Amazon River in 1924. His extensive experience with seaplane operation under widely varied conditions places him in an excellent position to speak with authority on seaplane bases. Lieutenant Hinton is now President of the Aviation Institute of the U. S. A., Washington, D. C.

Ralph H. Upson, airship engineer, was born in New York City in 1888 and made his first balloon flight in 1906. Since that time he has been continuously engaged in aeronautical development, more particularly as regards airships. He was for many years with the Goodyear Tire & Rubber Company and introduced the water model system of testing airship gas containers in 1912. Mr. Upson served as a member of the Navy Design Mission in Europe, 1918-1919, and won the National Balloon Races in 1919 and 1921. In 1920 he started work upon the development of the "metalclad" airship, a new type in which the fabric gas bags are replaced by all-metal containers. From 1920 to 1927 he devoted himself to this problem and accomplished some very important work. At present Mr. Upson is in charge of research and development for the Aeromarine-Klemm Corporation, Keyport, N. J.

Wallace Kellett graduated from Princeton in 1913 and served in the French Aviation Service during the World War. After the close of the War, he became American representative of Farman, Anzani, Breguet and other important French aviation concerns. Together with C. T. Ludington he organized the B. B. T. Corporation of America for the development and sale of aviation lighting equipment. This company carried out the lighting of the first night air mail route, from Chicago to Cheyenne and has since been actively engaged in developing and installing lighting equipment on many other airways. Mr. Kellett is the author of numerous technical articles on aviation and is Secretary-Treasurer of the B. B. T. Corporation of America.

H. C. Ritchie was born in Nova Scotia in 1888 and has been engaged in electrical engineering for many years. He is Aeronautical Specialist for the General Electric Company and, in this capacity, has been associated with the design and application of aviation lighting devices, particularly in connection with equipment of U. S. Air Mail routes. He has been a contributor to the technical press of articles on aviation lighting and is numbered among the authorities on this subject.

R. W. Cost is on the staff of the Westinghouse Lamp Company, Bloomfield, N. J., and assigned to the aviation lighting work of its Commercial Engineering Department. Mr. Cost is a lighting engineer who has specialized on airport and airways illumination for the past several years. He is also the author of some technical articles on this subject.

P. R. Bassett was a member of the First War Committee on Aviation Lighting appointed by the Illuminating Engineering Society in 1927 and thus had an early introduction to this problem. He was Lecturer on Aviation Lighting, Guggenheim School of Aeronautics, 1926 and 1927, and has been connected with the development of airway beacons and airport floodlights since 1916. He now holds the position of Research Engineer with the Sperry Gyroscope Company, Brooklyn, N. Y.

A. V. Conover is Vice-President of the Interflash Signal Corporation, New York, builders of flashing type acetylene beacons.

L. M. Merrill is manager of the Marine and Aviation Division, American Gas Accumulator Co., which company supplied much of the beacon equipment used on the original night air mail route. Mr. Merrill has given considerable attention to both marine and aviation beacons with particular regard to visibility under varying weather conditions and one of his charts on this subject is included in the Chapter on Lighting.

Malcolm P. Hanson is at present Radio Engineer of the Byrd Antarctic Expedition and has been engaged in radio engineering for several years. Just prior to his joining the Byrd Expedition he was on the staff of the Naval Radio Laboratory at Anacostia, D. C.

Dr. J. H. Dellinger has been, for many years, a recognized authority on radio. Born in Cleveland in 1886, he was educated in East High School of that city, in Western Reserve University and George Washington University. He received degree of A. B. at George Washington in 1908, and of Doctor of Philosophy at Princeton in 1913. Since 1907 he has been on the staff of the Bureau of Standards as a Physicist and has been Chief of Radio Section since 1919. He is author of books and articles on the subject of radio and in 1925, was President of the Institute of Radio Engineers. Dr. Dellinger is a member of numerous technical and scientific societies and is at present Chief Engineer of the Federal Radio Commission.

S. W. Goulden graduated from Norfolk, Va., Academy and completed his education at the University of Virginia where he specialized in electrical communication. In 1914 he completed the student course in telephone engineering at the Hawthorne Shops of the Western Electric Company. From 1914 to 1919 Mr. Goulden was associated with the Western Electric Company Laboratory in New York and in 1919 he joined the staff of the Marconi Wireless Telegraph Co., which company was later acquired by the Radio Corporation of America. He is at present Commercial Engineer for the latter company and in this capacity has had extensive contact with radio equipment for aviation purposes. He is a member of the Institute of Radio Engineers and a Fellow of the Radio Club of America.

James H. Kimball, meteorologist, was educated at Michigan Agricultural College and the University of Richmond and now holds degrees of B. S., M. A., and Ph. D. He has been on the staff of the U. S. Weather Bureau since 1895 and since the development of aviation has given particular attention to aeronautical meteorology.

He acted in the capacity of meteorological adviser at New York for the French High Commission, as meteorological instructor for flying units, and as consultant to troop dispatching agencies in the war years of 1917 and 1918. In 1927 he was faculty lecturer on aeronautical meteorology, New York University. Dr. Kimball has been well known in aviation for many years and acted as meteorological advisor of the trans-Atlantic flights of Lindbergh, Chamberlin, Byrd, Bertaud, Brock, Haldeman and Stultz.

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